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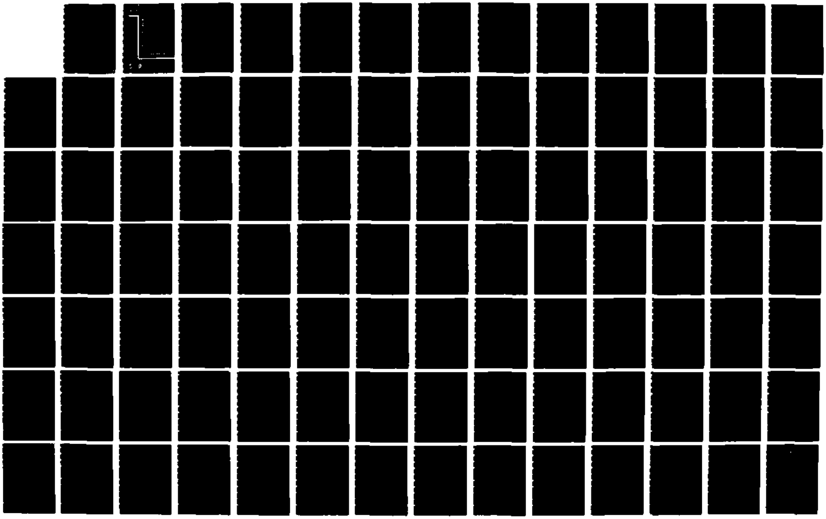

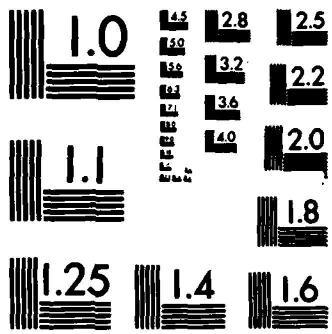
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AIR FORCE

HUMAN RESOURCES

AN EMPIRICAL SYSTEM FOR ASSESSING THE IMPACT OF APTITUDE REQUIREMENT ADJUSTMENTS ON AIR FORCE INITIAL SKILLS TRAINING

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Research was undertaken to develop a system for predicting the impact of aptitude requirement adjustments on Air Force initial-skills training. To accomplish this objective, a multivariate modeling approach was employed. Initially, interviews were conducted with a variety of technical training personnel to identify significant student input, course content, and training outcome variables. Measures of the identified variables were then formulated on the basis of personnel records and routinely available training documents. Subsequently, measures of the variables were obtained for 39 initial-skills courses and some 5,000 trainees. Information obtained from the interviews and the relationships observed among these variables gave rise to a hypothetical model of initial skills training, which was then validated through a formal path analysis. The resulting model accounted for a large amount of the variation in training outcomes and was found to yield path coefficients that were highly interpretable in predicting training outcomes. When cross-validated using a sample of nine additional training courses including approximately 1,000 trainees, the model yielded predicted training outcomes which were consistent with actual training outcomes. The implications of model components for understanding resident initial-skills training are discussed, along with potential applications of the model for personnel and training management.

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SUMMARY

The objective of this research and development (R&D) effort was to develop and validate an empirical procedure for predicting training outcomes associated with initial-skills courses administered by the United States Air Force Air Training Command. The R&D consisted of the collection and analysis of information to determine the effects of student attributes and course properties on training outcomes such as academic training performance and student elimination. The value of the procedure resides in its use as a decision support system for personnel and training management. It can be applied on a course-by-course basis to evaluate "what-if" questions concerning the effects of changes in student and course characteristics on training outcomes. For example, the system could be used by personnel managers to forecast the training outcomes likely to result from decreases in the minimum aptitude test score required for entry into an initial-skills course. It could be used by training managers to forecast the training outcomes likely to result from increases or decreases in the trained personnel requirement for the course. It could be used by course designers to forecast the training outcomes likely to result from adjustments in course length or student/instructor ratio. In addition to providing a means of forecasting training outcomes associated with changes in single variables, it could be used to forecast training outcomes associated with simultaneous adjustments in several student and course characteristics. The payoff of this R&D is a decision support system for personnel and training management that can be applied to anticipate and avoid adverse training outcomes.

PREFACE

This R&D is one of several efforts conducted in support of Request for Personnel Research (RPR) 73-17, Minimum Aptitude Requirements for Air Force Enlisted Specialties. The primary objective of research conducted in support of the RPR was to develop an empirical procedure for evaluating aptitude requirement minimums for enlisted specialties. Such a procedure was developed and is described in an AFHRL technical report by Burtch, Lipscomb, & Wissman (1982) and a special report by Weeks (1984). The R&D described in this report extends the focus of the research to include development of a system for assessing the impact of aptitude requirement adjustments on initial-skills training. The emerging system is potentially useful not only for avoiding the adverse effects on training outcomes of changes in student aptitudes but also for avoiding the adverse effects of changes in initial-skills courses. The research was accomplished under work unit 7719-19-10 and supports the Manpower, Personnel, and Training Integration subthrust and the Manpower and Force Management thrust.

Credit is due the Air Force Manpower and Personnel Center, Directorate of Assignments, Skills Management Division, USAF Classification and Training Branch (AFMPC/DPMRTC), Randolph AFB, TX, for support of the project under RPR 73-17. The research could not have been conducted without the generous support of the Air Training Command (ATC). Resources provided by ATC and authorization to conduct the R&D are documented in ATC Training Research Agreements #120 and #136. Because so many individuals participated in the project, space limitations do not permit mentioning them all by name. Training personnel located at each of the following organizations participated in the project: Air Force Military Training Center (AFMTC), Lackland AFB, TX; the 3700th Technical Training Wing (TCHTW), Sheppard AFB, TX; the USAF School of Health Care Sciences, Sheppard AFB, TX; the 3400th TCHTW, Lowry AFB, CO; the 3330th TCHTW, Chanute AFB, IL; and the 3300th TCHTW, Keesler AFB, MS. Credit is especially due course instructors and instructor supervisors for taking time from their busy schedules to provide information during initial interviews. Credit is also due personnel of the registrar's office at each training wing for their assistance in obtaining student training records. Finally, credit is due Headquarters ATC, Deputy Chief of Staff Technical Training, Plans Directorate, Research and Technology Division (HQ ATC/TTXR) for assistance in coordinating the data collection effort.

This report has been produced while R&D continues under work unit 7719-19-10 for the purpose of developing a computer-based system to facilitate application of the model. User-friendly software which implements the various parameters of the model has been developed under the acronym TTIM (Technical Training Impact Model). This effort will be documented in subsequent reports. In addition, final test and evaluation efforts are being coordinated to serve as a basis of transitioning the technology to HQ ATC.

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I. INTRODUCTION

Background

Although many factors influence the effectiveness of an organization, it has long been recognized that individual performance is one of the most important determinants of goal attainment in any group undertaking. As a result, a wide variety of studies have been conducted in an attempt to delineate the variables that influence individual performance, and to determine how these variables interact with situational constraints to influence organizational effectiveness. Among the variables examined in these studies, the allocation of individuals to jobs has proven to be of special significance, due to the fact that individuals differ markedly in their willingness and capability to perform various tasks (Dunnette, 1966). For instance, Schmidt, Hunter, McKenzie, and Muldrow (1979) have shown that a single organization may save itself millions of dollars each year by assigning to jobs only those individuals who possess the attributes necessary to satisfactorily perform those jobs.

Recognition of the fundamental importance of optimal manpower allocation has led many organizations to invest substantial time and energy in the development of decision rules for assigning individuals to jobs. Typically, this is accomplished through the use of standard selection inventories to assess the extent to which an individual possesses the attributes required for adequate job performance. However, in other instances, it has been necessary to employ a more general and complex classification system in which the individual is considered for assignment to a number of alternate jobs on the basis of his/her attributes and organizational needs (Magnuson, 1966). Application of the more complex classification paradigm for manpower allocation has generally been found to be most useful when the organization must obtain adequate performance in a large number of jobs within a finite timeframe and manpower pool.

The Air Force is perennially faced with conditions that underscore the need for effective classification. Because Air Force technical training is expensive and time-consuming, and because it constitutes a hurdle that most airmen must pass before they can be assigned to Air Force specialties (AFSs), classification decisions have been based, in part, on expected training success. In this regard, it should be noted that effective allocation of individuals with respect to job training programs is not associated solely with short-term benefits. As Maginnis, Uchima, and Smith (1975a, 1975b, 1975c) have pointed out, inappropriate allocation of Air Force enlistees to training programs may result in a number of costly long-term outcomes ranging from poor job performance to high turnover. When these negative outcomes of inappropriate job classification decisions are aggregated over tens of thousands of individuals, they can have a substantial impact on Air Force efficiency and mission readiness.

Personnel Allocation in the Air Force

Given the foregoing concerns, it is hardly surprising that a cohesive classification strategy has emerged in the Air Force. As implied by the previous discussion, any effective personnel allocation system requires two central pieces of information: (a) a definition of the performance-relevant attributes possessed by the individual, and (b) a system for relating personnel attributes to effective job performance.

In the Air Force, attributes of the individual are assessed primarily through the Armed Services Vocational Aptitude Battery (ASVAB) (Weeks, Mullins, & Vitola, 1975). The ASVAB is a

cognitive abilities test battery composed of a set of aptitude tests ranging from general verbal and quantitative measures to specialized measures of technical knowledge. The Air Force combines the tests contained in the ASVAB to form four aptitude test composites. These four aptitude composites are designed to measure an individual's aptitude for Mechanical, Administrative, General, and Electronics job specialty areas. The ASVAB aptitude composites display reliabilities in the mid-.80s and validities against a criterion of technical training success in the mid-.60s (Weeks, Mullins, & Vitola, 1975). The scores on the aptitude composites constitute the principal measures employed by the Air Force for describing characteristics of the individual likely to influence subsequent training and job performance.

Although ASVAB aptitude composites constitute the principal description of the individual used in the Air Force manpower personnel allocation system, other descriptors are employed as well. For instance, the educational level and the educational preparation of the enlistee are considered, as are expressed interest for a given specialty and the individual's physical capabilities. In addition, access to certain specialties may be limited by manpower requirements and administrative requirements, such as obtaining a security clearance.

The system the Air Force employs for relating performance on the ASVAB to organizational needs is relatively straightforward. Essentially, it is based on the concept that the most talented individuals should be assigned to the most demanding AFSs. In the Air Force context, talent for various specialties is defined in terms of the individual's scores on the ASVAB aptitude composites. Thus, under ideal conditions, individuals with high scores on the Electronics composite would be assigned to the most difficult electronics specialties. One way the Air Force has attempted to implement this assignment rule is by specifying minimum aptitude requirements for entry into each AFS.

For the personnel allocation strategy described above to serve its intended purpose, aptitude requirement minimums must correspond to the occupational demand or difficulty of job specialties. In setting aptitude requirement minimums, technical training attrition rates have served as an index of difficulty. Although this index of difficulty appears reasonable, changes in training programs and manpower requirements, as well as more general administrative concerns, have led to changes in technical training attrition rates and, therefore, aptitude requirement minimums that are not necessarily in line with the difficulty of the job. For example, Weeks (1984) found a less-than-perfect relationship between the aptitude minimums assigned AFSs and experts' judgments of job difficulty. Because the optimal allocation of talent depends on a close match between aptitude requirement minimums and the relative difficulty of job specialties, misalignments between aptitude requirements and job difficulty lead to assignment errors, and to corresponding effects on Air Force mission readiness.

Defining Occupational Difficulty

The definition of occupational difficulty represents a salient problem. First, it is clear that training attrition rates can produce only an approximate measure of difficulty since they reflect training requirements as opposed to job requirements. Second, attrition rates are influenced by a variety of training-specific factors (such as the appropriateness of instructional materials or the availability of faculty resources) that may result in a biased index of difficulty. Thus, it appears that in implementing its manpower allocation system in the most effective manner possible, the fundamental problem facing the Air Force is to find a more appropriate measure of relative occupational difficulty.

The fundamental import of this problem and its potential impact on the overall effectiveness of the Air Force, via its implications for personnel allocation, led to the requirement for the Air Force Human Resources Laboratory (AFHRL) to undertake an extensive series of research and development (R&D) efforts intended to establish a more general and accurate measure of the

relative difficulty of enlisted job specialties. Although there are obviously many potential obstacles involved in attempting to assess the difficulty of any career field, we believe that AFHRL has formulated a viable approach to this problem through the construct of occupational learning difficulty.

Occupational learning difficulty is defined as the time it takes to learn to perform an occupation satisfactorily (Weeks, 1984). The construct is based on the premise that, with ability held constant, individuals will take a longer time to learn to perform a more difficult occupational task than a relatively easy one (Christal, 1976). This appears to be a well-founded assumption. In fact, substantial support for this proposition may be found in the research literature with respect to its corollary that more capable individuals will take less time to learn a task of constant difficulty (Cronbach & Snow, 1977). Moreover, the recent cognitive processing literature also strongly supports the proposition that time-to-mastery and response time may be excellent indicators of problem difficulty at both the individual and the aggregate levels (Sternberg, 1982). Thus, it appears that there is sufficent evidence in the literature to indicate that the time taken by an individual to learn a task is an appropriate definition of difficulty.

If it is granted that "time to learn" provides an adequate index of the difficulty of an activity, then the next question to be answered is how this conceptualization of difficulty might be translated into an operational measure. In addressing this problem, the Air Force employed a job analysis approach in which the time it takes to learn to satisfactorily perform occupational tasks is evaluated by subject-matter experts (Christal, 1976). More specifically, AFHRL developed a set of benchmark rating scales against which the learning difficulty of the tasks performed in specialties within the Mechanical, Administrative, General, and Electronics job specialty areas could be evaluated (Fugill, 1972, 1973). Subsequently, experts evaluated tasks within each specialty against the appropriate benchmark rating scale, and a weighted composite of these task ratings was obtained to determine the overall learning difficulty of the specialty (Weeks, 1981). Research has shown that these task ratings are highly reliable and display considerable convergent validity (Burtch, Lipscomb, & Wissman, 1982).

The foregoing investigations indicated that it is possible to employ ratings of the learning difficulty of occupational tasks in evaluating overall occupational difficulty. Moreover, this research demonstrated that measures of occupational learning difficulty could be obtained through a relatively straightforward extension of the Air Force's current job analysis system (Christal, 1976). Consequently, it appeared that the occupational difficulty measure might provide a fully adequate and administratively feasible basis for defining the relative difficulty of occupations. If this measure were in turn used as a frame of reference in establishing job aptitude requirement minimums, it was felt that it might improve the current personnel allocation system. However, preliminary analyses (Weeks, 1984) have indicated that the realignment of aptitude minimums in accordance with occupational learning difficulty would lead to marked shifts in aptitude minimums for several specialties.

The Problem

A wide variety of studies have indicated that scores on aptitude measures are directly related to educational performance. For instance, Tyler (1964) summarized a number of studies and concluded that general cognitive ability has a marked impact on training performance, such that higher aptitude students not only perform better on achievement tests but also seem to profit more from education. Similarly, in the Air Force context, Wilbourn, Valentine, and Ree (1984) found that performance on the ASVAB is substantially related to training performance in a number of different occupational fields.

Obviously, intellectual aptitude is not the only variable that can influence training performance. For instance, it has been pointed out that interest, general achievement motivation, specific educational preparation, reading ability, maturity, study habits, and self-discipline, among other variables, may also affect training performance (Frederickson & Gilbert, 1964; Gough & Fink, 1964). Moreover, as Terman (1959) pointed out, all these variables interact with general cognitive ability in subtle but generally positive ways. As a result, it is critical that any effort to align aptitude requirement minimums with occupational learning difficulty include careful consideration of the impact of such aptitude requirement adjustments on technical training outcomes. Further, one must consider not only the direct effects of aptitude but also the indirect effects that aptitude has on other individual attributes related to training performance.

In considering the potential impact of aptitude requirement adjustments on training performance, there is another set of variables that should be considered. Currently, the Air Force formulates instructional programs through a variation of the instructional systems development (ISD) paradigm proposed by Goldstein (1974) and elaborated by O'Neil (1979) among others. As with most well-designed instructional systems, the characteristics of the student population are carefully examined, including educational preparation, reading ability, aptitude, and motivation. Thus, the indirect impact of aptitude requirement adjustments on technical training might be manifested not only through other attributes of the individual, but also through the design of training materials and course variables such as the length of training.

It should also be recognized that the impact of aptitude on training performance might itself be moderated by course content variables, and that aptitude may interact with these variables in determining training outcomes. For instance, Cronbach and Snow (1977) reviewed different sources of evidence that, while not conclusive, do suggest that features of the instructional process may interact with aptitude and other individual attributes in determining training outcomes. It should be noted here that similar effects have been observed in the military setting in studies conducted by Fox, Taylor, and Caylor (1969), as well as Federico and Landis (1979).

Taken as a whole, the preceding discussion indicates that changes in aptitude requirement minimums will lead to changes in training performance. However, it is difficult to specify the exact nature and magnitude of these changes since the effects of aptitude may be moderated by other individual attributes and by various characteristics of the particular training program.

This ambiguity was of sufficient concern to Air Force training and personnel managers that it was felt that before any major adjustments were made in aptitude requirements on the basis of occupational learning difficulty, R&D should be conducted to provide some insight into the impact of such aptitude requirement adjustments on technical training outcomes. Finally, it was argued that the investigation should carefully consider those complex attributes of both students and training programs that might interact with aptitude in determining training outcomes. The present investigation was undertaken in an attempt to meet these goals.

II. METHOD

Overview

A variety of different methodological strategies might be employed to address the concerns outlined previously. However, the nature of Air Force initial-skills training, along with the goals of the present effort and the pertinent research literature, indicated the need for a particular methodological and conceptual approach. In reviewing the relationship between cognitive abilities and training outcomes, it became apparent that the effects of aptitude on training outcomes could adequately be captured only by considering a variety of student

attributes related to aptitude, such as academic motivation and educational level, as well as the potential interaction of aptitude and associated variables with aspects of the training process associated with a given specialty. Moreover, Kirkpatrick (1959) noted that multiple training outcome variables must be examined in any attempt to assess training performance. For example, when examining technical training outcomes, it is clear that the quality of student performance must be considered as well as student attrition rates. These observations taken as a whole suggest that any attempt to address the issues at hand must take a multivariate approach capable of incorporating a variety of student input, course content, and training outcome variables.

In addition to a multivariate approach, practical considerations require that the relationships established among these variables must be capable of being used in making routine predictions. This requires that measures of these variables be applicable to all technical training courses under consideration. When this observation was coupled with the fact that R&D examining training outcomes would be feasible only to the extent that it did not disrupt ongoing training efforts, a correlational field study seemed the most appropriate approach. Finally, because the Air Force Air Training Command (ATC) currently administers approximately 200 resident, initial-skills training courses, it was apparent that the student input, course content, and training outcome variables, as well as their interrelationships, could not be established separately for each course. Thus, it seemed necessary to employ general descriptive variables in each of these areas and attempt to establish typical relationships across a variety of initial-skills courses.

In view of these considerations, it was decided to use the modeling strategy of path analysis, which is an extension and generalization of the traditional regression model and which, like the regression approach, allows predictions in such a way that permits multiple causal relationships to be considered. This decision was supported by the fact that multivariate models have proven useful in addressing a variety of complex problems in the social sciences, ranging from interest development (Ekehammar, 1977) to the determinants of collegiate academic performance (Ribich & Schneck, 1979). An excellent overview of this diverse literature, as well as illustrations of the potential applications of this approach in addressing problems involving multivariate prediction, may be found in Joreskog and Sorbom (1980).

After it was determined that a multivariate modeling approach would be most appropriate for addressing the problems at hand, the next issue to be resolved was how this approach should be implemented. Generally speaking, the use of a multivariate modeling approach is contingent on the formation of a sound theoretical framework (Kenny, 1979). This theoretical framework in turn serves as a guide for determining the nature of the variables that should be included in the model, as well as their hypothetical interrelationships. The model is then tested by contrasting theoretical expectations, and the variance-covariance matrix they imply, against an empirical variance-covariance matrix derived from a set of observations. If the theoretical model fits the data, one can have confidence in its appropriateness. The weights generated in fitting the theoretical model to the observed data may then be used as a basis for prediction.

The foregoing overview of the path analysis served to outline the general methodological steps employed in the present investigation. First, a general conceptual framework for understanding the relationships among student inputs, course content, and training outcomes was formulated. Second, this theoretical framework guided the specification of the variables likely to influence training performance. Third, adequate measures of these variables were developed or obtained. Fourth, the measures were applied to a number of different individuals in a representative sample of initial-skills courses. Fifth, the observed relationships among these variables were evaluated in light of the model. Of course, modifications were made to this general methodological framework as a result of practical constraints. For instance, investigators commonly modify their initial theory once correlational data become available if

any limitations in their original theory become apparent. Nevertheless, these steps constitute the general method employed in the present investigation.

The Conceptual Model

The preceding section suggested some ways aptitude can influence performance in training. This section will develop this relationship in more detail, starting with the most straightforward relationship, which assumes that aptitude directly causes training performance. Model A of Figure 1 schematically depicts this relationship. Although this may be an appropriate conceptualization in situations where the aptitude measures are heavily weighted toward prior achievement, in the context of the present effort, it is unlikely that such a simple, direct relationship exists, since the ASVAB is a general measure of intellectual ability and most Air Force enlistees have little prior experience with the work required in the specialties for which they are trained.

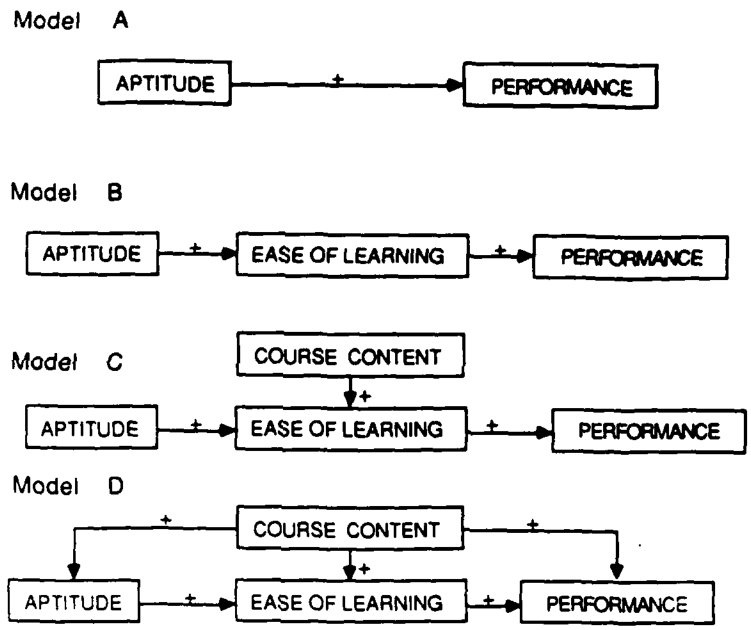

Figure 1. **Initial Conceptual Models.**

These observations suggested that some fundamental intervening processes must link aptitude to training performance. There can be little doubt that this intervening process is learning. This extension of the simple, direct linkage model is presented in Figure 1 as Model B. In this case, aptitude facilitates ease of learning, which in turn facilitates training performance, given a constant training time. This extension of the initial model is supported in a literature review by Cronbach and Snow (1977), who summarized a number of studies indicating that aptitude generally leads to more rapid attainment of training performance standards. Moreover, additional support for the extended model is suggested by its alignment with the theory underlying the occupational learning difficulty research conducted by AFHRL.

When ease of learning is conceived of as a hypothetical variable intervening between aptitude and performance, the significance of, and need for, a second class of variables becomes apparent. One of the principles underlying instructional systems development is that performance in training can be enhanced by the use of effective training strategies (Goldstein, 1974). This suggests that variables that characterize the training program and that might influence ease of

learning, such as quality of instruction and amount of feedback (Latham & Wexly, 1980), should be included in the model. Model C presents a revision of Model B which incorporates training variables. However, it should be recognized that, as well as having an impact on ease of learning, these course content variables may also have a separate impact on performance. For example, instructor-student interactions may affect evaluations of student performance, in addition to having an impact on ease of learning. Thus, it was necessary to consider the possibility that course content variables may have a direct impact on performance. Moreover, it should be noted that because initial-skills training courses are designed in relation to the student population, aptitude itself may also have a direct impact on these course content variables. These considerations led to Model D.

Support for Model D is also found in the literature. This model postulates a complex set of interactions between aptitude and course content variables and holds that both classes of variables may have direct effects on performance. Phenomena of this sort have been observed in a variety of studies including those conducted by Smith (1942) and Newman, Freeman, and Holzinger (1937). Yet, despite the existence of such support, this version of the conceptual model is still incomplete. The literature reviewed earlier suggests that any effects of aptitude on training performance may be expressed through or moderated by other student inputs such as reading ability or academic motivation, which are themselves related to aptitude. As a result, it seems that the aptitude component of the model should be expanded to include a variety of performance-relevant attributes of the individual. However, it should be recognized that variables such as motivation may themselves have a direct impact on performance which is independent of their impact on ease of learning. Finally, it should be noted that although training performance represents an abstract construct, it is manifested in a variety of training outcomes which, in some way, have cost implications for the Air Force.

The foregoing considerations led to a further revision of the initial conceptual model. This model, presented in Figure 2, represents the general conceptual model employed in the present investigation. As may be seen, both course content variables and student inputs were held to have positive causal effects on training outcomes, as indicated by the plus signs and arrows. Student input and course content variables were also held to be capable of having a direct causal effect on training outcomes regardless of ease of learning. Finally, ease of learning was assumed to have a direct positive causal effect on training outcomes, and adverse training outcomes were assumed to have a negative effect on training costs. Basically, the general conceptual model indicates that training outcomes are a function of student inputs and course content, and that these outcomes in turn affect training costs. This rather straightforward conceptualization provided the preliminary theoretical framework required to develop an empirical model of the relationship between aptitude and training outcomes.

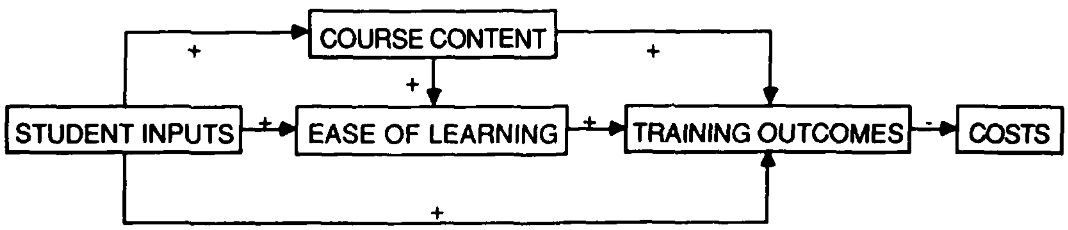

Figure 2. Refined Conceptual Model.

Variable Specification

Following development of the general conceptual model, the next step in this effort involved identifying the student input and course content variables capable of influencing ease of learning, as well as the likely relationships among these variables. Once these variables had been identified, it was then necessary to generate measures of these variables and ensure the relevance of these measures to training performance. In order to obtain this information, it was necessary to conduct a series of interviews with Air Force personnel directly involved in the technical training process.

A set of preliminary interviews was conducted at Headquarters Air Training Command (HQ ATC) by two Advanced Research Resource Organization (ARRO) staff members and two representatives of AFHRL. Interviewees were drawn from organizational groups charged with the overall control and coordination of technical training. These interviews were not highly structured but served to provide an overview of the technical training process. Additionally, at this time, a sample of documentary materials were obtained including:

1. ATC Forms 156, Student Record of Training,
2. plans of instruction (POIs),
3. specialty training standards (STSs), and
4. course charts (CCs).

The information obtained in the preliminary interview was then used to design a more structured interview protocol to elicit information pertaining to:

1. variables indicative of the quality of student training performance;
2. student input variables that might influence training performance quality;
3. course content variables that might influence training performance quality;
4. probable relationships between course content and student input variables;
5. potential measures of student input, course content, and training outcome variables;
6. potential biases in these measures; and
7. potential sources of these measures.

An example of the interview protocol appears in Appendix A. Once this interview protocol had been developed, a series of visits were then made to four ATC technical training centers: Lowry AFB, Keesler AFB, Sheppard AFB, and Chanute AFB. At each site, interviews were conducted with:

1. course instructors,
2. instructor supervisors,
3. training managers,
4. instructional systems design chiefs,

5. wing educational advisor,

6. measurement section personnel, and

7. registrar.

These individuals were chosen so that several different perspectives of the technical training program would be represented. During the interviews, an attempt was made in all cases to focus discussion on those questions contained in the general interview protocol most relevant to the interviewees' areas of expertise.

The interviews were conducted by two ARRO staff members and two AFHRL representatives during the winter of 1983. One ARRO staff member was responsible for guiding the discussion, while the other was responsible for generating a written summary of the discussion. The written summaries obtained from these interviews were subsequently reviewed by ARRO staff members in an attempt to identify: (a) the major measurable outcomes of resident technical training, (b) the student inputs likely to influence outcomes within each course (and across courses), and (c) the course content variables likely to influence outcomes within each course (and across courses).

The review also focused on (a) the interrelationships among student input and course content variables across courses, (b) the available measures of these constructs, and (c) any known biases in these measures. Once this information had been obtained, it was used to specify the variables that would be considered for inclusion in the model.

Variables and Measures

The variables considered for inclusion in the model were selected on the basis of information collected during the interviews. Because specification of variables constitutes a critical step in the development of a valid multivariate model, substantial attention is given to this topic below. This discussion begins with an examination of training outcome variables and then turns to the student input and course content variables.

Training Outcomes. To understand the significant outcomes of initial-skills training in ATC, it is necessary to have some understanding of the goals of the training effort. In the Air Force, initial-skills training is not intended to produce a fully qualified journeyman capable of performing all tasks within a specialty. Rather, students are trained to a level of partial proficiency in the tasks they are most likely to perform upon job entry. In the Air Force, this is called "training to the 3-skill level." The assessment of trainee performance focuses on the acquisition of knowledge and performance capabilities associated with this skill level. Assessment procedures are prescribed in ATC Regulation 52-3, Student Measurement Guidelines. This document, which is presented in Appendix B, serves to specify exactly how and when students should be evaluated. Although this regulation allows for some local variation in student evaluation procedures, its content has led to the emergence of a relatively standard set of procedures.

Typically, a technical training course is divided into units that present a cohesive body of material and blocks of instruction that are composed of varying numbers of units. Within each unit, quizzes or progress checks (PC) that have been formally specified in the course Plan of Instruction (POI) are administered. Students must pass each PC before being allowed to advance to the next unit. If the student fails a PC, the instructor is expected to provide Special Individual Assistance (SIA) until the PC has been passed, although SIA may be provided for other reasons as well. Once the student has passed all PCs in a block, an end-of-block written test is administered. This end-of-block test is a standard paper-and-pencil academic achievement test.

The student must obtain a minimum score of 70 on the block test to advance to the next block of instruction. If a failing grade is obtained, the student may be required to repeat the block of instruction before retaking the test. Failure to pass on the second attempt usually leads to student elimination.

All student evaluations are recorded. Progress check performance is recorded on ATC Form 98, Student Progress Checklist, which is destroyed once the student has completed the course. End-of-block tests are recorded on ATC Form 156, Student Record of Training, which is maintained by the training center registrar's office as a permanent record of an individual's training performance. An example of ATC Form 156 is provided in Appendix C. A student's final grade for the course is the average of all end-of-block tests. The consensus of the interviewees was that the average final course grade is an adequate, if not excellent, index of the quality of student performance. Therefore, final course grade, as defined by average performance on the block tests, was used to provide an index of the quality of student training performance in the model.

ATC Form 156 also provides a variety of additional information bearing on training performance. One such item is hours of SIA time provided the student. Interviewees indicated that SIA time was accurately recorded, and that it was a costly and important outcome. Thus, it seemed prudent to consider SIA time as an additional training outcome.

ATC Form 156 also contains information concerning two other outcomes that interviewees considered to be of substantial importance. All negative actions concerning a student, such as elimination from training or scheduling for retraining, must be preceded by a counseling session. In these counseling sessions, which usually last about an hour, student performance is reviewed by an instructor supervisor who talks to the student and determines what action should be taken. The numbers of academic and nonacademic counseling sessions are recorded on the ATC Form 156, and it is noted whether each session was held for academic or nonacademic reasons. Given their importance, it seemed necessary to quantify counseling sessions as a training outcome. This was done by determining separately the total number of academic and nonacademic counseling sessions a student received during the course.

Another potential outcome of training (i.e., an alternative index of student performance) is retraining time. Retraining occurs when a student is required to repeat one or more blocks of a course as a consequence of failing an end-of-block test. This outcome is significant in part because retraining is remedial action taken prior to elimination for academic reasons, and in part because retraining is quite expensive. A measure of retraining time may be obtained from the ATC Form 156 by subtracting the formal course length from the individual's total hours in training.

As implied by the foregoing discussion, nearly all groups interviewed indicated that two of the most important training outcomes are academic and nonacademic elimination. Both academic and nonacademic eliminations are directly recorded on ATC Forms 156. This information was used to code as 0's students who graduated and to code as 1's students who were eliminated from training for either strictly academic or strictly nonacademic reasons (not administrative reasons such as death or lack of a security clearance). Students who were eliminated presented a special problem with respect to the measurement of SIA time, retraining time, academic counseling, nonacademic counseling, and the quality of student performance. The problem was to estimate expected values for these variables which probably would have been observed if the student had remained in the course for the entire training period. The expected value of quality of student performance was estimated by taking the average of all block test grades up to the point of elimination. For SIA time, retraining time, academic counseling, and nonacademic counseling, the expected values were estimated by calculating the rate per training hour up to the point of elimination and increasing the observed value at the point of elimination by the product of training hours not completed and the rate per training hour.

Overall, seven training outcomes were identified as being significant variables: assessed quality of student performance, SIA time, retraining time, academic counseling, nonacademic counseling, academic attrition (i.e., student elimination), and nonacademic attrition. Measures of all these variables could be obtained from the permanently maintained ATC Form 156. Although performance on PCs would seem to be a potentially significant outcome variable, this information was no longer available. Based upon these observations, coupled with interviewees' comments that the student evaluation data were accurately recorded and represented a comprehensive description of training performance, it seemed reasonable to conclude that these measures would provide an adequate basis for model development.

Student Inputs. Practically all interview groups agreed that a student's aptitude significantly influences training outcomes. In the Air Force, at least three measures of aptitude are available: Armed Forces Qualification Test (AFQT) score, ASVAB subtest scores, and scores on the ASVAB aptitude composites. Given current Air Force classification practices, it was decided that the ASVAB aptitude composite score should be used as the principal index of aptitude. This decision also finds some support in the fact that the aptitude composite scores have been shown to be reliable and valid predictors of technical training performance (Wilbourn et al., 1984). In the present effort, although it was possible to use all four aptitude composite scores as indicators of student aptitudes, it was deemed more appropriate to use only the aptitude composite score that applied to the specialty for which the individual was being trained.

Although all interviewees considered aptitude to be of great importance, they also noted that a number of other student characteristics interacted with aptitude in determining training performance. For instance, trainers noted that reading ability often had a substantial impact on training performance, due to the reading difficulty of the technical material used in certain courses. Currently, two measures of reading ability are available on the ATC Form 156 which reflect vocabulary and reading comprehension levels. These measures are derived from the Air Force Reading Abilities Test (AFRAT), which is currently administered during basic military training. Alternate forms of this test have reliabilities ranging between the mid-.80s and low-.90s (Mathews & Roach, 1982). Given the availability of these measures and the perceived effect of reading ability on training outcomes, AFRAT scores were included in the model as an average of the vocabulary and reading comprehension scores.

In addition to aptitude and reading ability, course supervisors and instructors emphasized the importance of educational preparation because of its relation to study habits and ability to cope with an academic environment. Currently, the Air Force does not use direct measures of educational preparation in the classification process; however, two indirect measures were available. The first of these was the educational level attained by the individual prior to entering the Air Force. These data are recorded in the Processing and Classification of Enlistees (PACE) personnel data file. For the present effort, this variable was scored on a 5-point continuum such that non-high school graduates received a score of 1, high school graduates received a score of 2, those with some college received a score of 3, college graduates received a score of 4, and those having post-graduate work received a score of 5. A second measure of educational preparation was also obtained from the PACE file. The PACE file contains a listing of some 42 different high school courses that could have been taken by the individual prior to entering the Air Force. For most specialties, the Air Force lists one to five of these courses as desirable prerequisites for entry into an AFS. Thus, an additional measure of educational preparation could be obtained by summing the number of suggested high school course prerequisites that the individual had completed prior to entering the Air Force. Although the reliability and validity of these particular measures were not established, available evidence concerning such background data measures suggests reliabilities in the mid-.90s as well as substantial predictive power.

The high school course records contained in the PACE file also made it possible to assess another student input deemed to be of some importance to training performance. The interview groups consistently underscored the importance of student motivation in determining training performance. Although neither the scope of the present effort nor the current Air Force classification procedures would permit the assessment of general achievement motivation, it was possible to build a measure of academic achievement motivation from the available background data. This was done by having five psychologists rate the overall difficulty of each of the 42 high school course prerequisites on a 5-point scale. The interrater reliability of these judgments was in the low-.90s. These ratings were used to develop an index of academic achievement motivation by forming a weighted sum of the difficulty of the high school courses taken by an individual. Although the reliability of this index is not known, given the reliability of academic history data and the reliability of the difficulty ratings, it appears that the reliability of the index would be fairly high. A list of the difficulty ratings assigned to the 42 high school courses is provided in Appendix D.

During the interviews, instructors and instructor supervisors often noted that the maturity of the student was of some importance in determining training outcomes. At least two indicators of maturity were available for use in the present effort. The first of these was age at the time of entry into training. The second was whether the student was a new enlistee, as opposed to being an experienced airman retraining for a new specialty. Although the latter measure appears to be a somewhat more direct index of vocational maturity, the infrequency with which experienced airmen are retrained into totally new specialties led to the use of age as a general index of maturity. Given the high reliability of this index, the limited age range involved, and the control for education level and aptitude already included among student inputs, inclusion of this measure seemed well justified.

Students' interest in the specialty for which they are being trained was also cited by many interview groups as having a significant influence on training performance; however, few indices of vocational interest are available in the Air Force. The most appropriate of these indices is the Air Force Vocational Interest-Career Examination (Alley, Wilbourn, & Berberich, 1976). Unfortunately, this measure is not yet in operational use and so could not be employed in the present effort. Two alternate indices of interest could also be identified, however. The first of these was a measure of whether the trainee had or had not been guaranteed training in a particular specialty as part of his/her enlistment contract. Trainees having guaranteed training were coded as 2; all others were coded as 1. The second of these, also obtained from the PACE file, was a combination of information concerning the specialty to which the trainee was assigned and a rank-ordering of the trainee's five specialty preferences. From this information, an interest index was derived by coding as a 5 trainees who got their first choice; by coding as a 3 trainees who got their second, third, fourth, or fifth choice; and by coding as a 1 trainees assigned to a specialty that was not ranked. Unfortunately, when selecting specialties for training, enlistees have little knowledge concerning the content and nature of the specialties. Thus, these two vocational interest measures were considered to be of limited value, and were only tentatively considered for inclusion in the model.

At least three other classes of student input variables were mentioned as being related to training performance. The first class of variables included factors such as resistance to stress, and attention to detail. Unfortunately, measures of these variables are not routinely collected. Moreover, their impact on performance appears to be AFS-specific, in the sense that resistance to stress was seen as being particularly important for Air Traffic Controllers but not for other specialties such as Personnel Specialists. This specificity argues against the use of such variables in formulating a general model of technical training; and so, for both pragmatic and theoretical reasons, variables of this sort were not included. A second class of student inputs mentioned as being related to training performance involved physical ability. However, the specificity of occupational physical demands and their limited relevance to classroom

performance led to the rejection this class of variables despite their use in the selection and classification process. Finally, demographic variables such as sex, ethnicity, and socioeconomic status were not considered for inclusion in the model because they have only an indirect relationship to training performance.

Despite the exclusion of these latter variables, it appears that the student input variables specified for inclusion in the model provide a reasonably comprehensive description of the relevant student attributes. Measures of the variables selected in the present investigation were obtained from the PACE file, with the exception of AFRAT scores, which were obtained from ATC Form 156. The ready availability of these measures and their general significance to training appeared to provide a sound practical basis for model development.

Course Content. In specifying the course content component of the model, a variety of course variables were mentioned by interviewees as being of some import. One of these variables was course length. It was often reported that time constraints were an important consideration in determining training outcomes and that given sufficient time, anyone could be trained. Such comments indicated that course length should be included in the model. This variable could be measured by simply obtaining the number of hours of classroom instruction specified in the course POI. In discussions with instructors and course supervisors, it was also noted that course training programs provided either a full 8 hours of lecture each day or 6 hours of lecture plus 2 hours of supervised study. Generally, they felt that what was called the "improved" or 6-plus-2-hour instructional day contributed to better performance because the information load on students was less, thus preventing student "burnout." Thus, the length of the instructional day was measured by coding an 8-hour day as a 1 and a 6-plus-2-hour day as a 0. In the case of both instructional day length and course length, these measures can be assumed to be perfectly reliable due to the highly structured and tightly scheduled nature of resident technical training.

Another topic that received a great deal of attention in the interviews concerned the quality and experience of instructors. Course supervisors and branch chiefs pointed out that instructor experience in the classroom often seemed related to the quality of student performance, as did the overall quality of the instruction provided to students.

Instructor quality is assessed through supervisory ratings and is recorded on ATC Form 281, Instructor Evaluation Checklist. This form is a behavioral checklist containing 19 nonadministrative items which had an interrater reliability (R^{kk}) of .83 for a sample of 100 instructors drawn from 48 different courses. These instructor evaluations are conducted at specified intervals, depending on the particular instructor's experience. Performance on each item is graded as good, satisfactory, or poor. These evaluations are retained as permanent records and could be easily obtained. Although some concern with their accuracy was voiced during the interviews, it was felt that they provided a useful index of the quality of the instruction being provided in a course. Ratings on each item were quantified by assigning good ratings a score of 3, satisfactory ratings a score of 2, and poor ratings a score of 1. The quality of individual instructors was calculated as an average of the item ratings, while quality of instruction at the course level was determined by averaging the ratings received by all instructors assigned to the course. Instructor experience presented a somewhat less complex variable in terms of measurement procedures since interviewees indicated that the number of months of instructional experience possessed by each instructor could be readily provided by course supervisors. Thus, a reliable index of course-level instructor experience could be obtained simply by calculating the average months of experience of all instructors assigned to the course.

For any given course, the ratio of the number of students to the number of faculty members was also considered as a variable contributing to student performance because the fewer students per instructor, the more instructional assistance time was potentially available to any one

student. It was noted that student-faculty ratio is a fixed course variable specified in the training plan (TP) developed for each course. Student-faculty ratio listed in the training plan was employed as a fully reliable measure of this course content variable.

The amount of feedback and practice given to students has long been considered to have an effect on training performance. This point was underscored by the training personnel interviewed. They pointed out that student assessment by means of PCs, and the resulting rapid feedback, improved later performance on the end-of-block written tests. The interviewees also indicated that formal feedback in terms of the progress checks and block tests was specified in the POI, and that this student evaluation schedule was rigidly adhered to. Thus, it was possible to generate a reliable measure of the amount of formal feedback in a course by summing the number of progress checks and block tests specified in the POI. However, it seemed necessary to control for course length in the development of this measure. Hence, this sum was divided by the total number of instructional hours to obtain an index of the amount of feedback per unit time.

To address the issue of practice, it was necessary to establish the average amount of training time students were given on a unified body of material. This was accomplished by determining the total number of units in a course and then dividing the total number of instructional hours by the number of units to determine the average amount of time on each unit of instruction. Again, this information was obtained from the POI. The documentary nature of these data would indicate perfect reliability for this measure, at least in the limited sense defined here. It should also be noted that since student evaluation in technical training is closely linked to the completion of instructional units, it was assumed that there would be a strong negative relationship between practice and feedback.

In the course of the interviews, instructors and instructor supervisors often stated that performance could be improved by the use of instructional aids and hands-on practice. It was noted that the number of aids, as defined by job task simulations, mockups, and direct use of job materials, was formally specified in the course POI by unit of instruction. Thus, a direct and reliable indicator of the extent to which instructional aids were used in a course could be obtained by counting the number of times mockups, job task simulations, or direct manipulations of job materials were required. Similarly, the POI specified the number of hands-on hours of instruction by course unit and so a reliable measure of this variable could be generated by summing the number of hands-on hours across instructional units. However, both the number of aids and the amount of hands-on training are obviously dependent on course length. To control for this biasing influence, both the total number of aids and the number of hands-on hours were divided by course length to yield indices of aids and hands-on practice per unit time.

When instructional systems design personnel, training managers, and educational advisors were interviewed, it was often pointed out that AFS manning requirements constituted a significant influence on the design of the associated course via a variety of direct and indirect routes, ranging from their influence on the aptitude of trainees to the frequency of feedback. Two indices of manning requirements were obtained. First, an index could be found in the number of students trained in a calendar year. Another index of manning requirements was found in the availability of a monetary reenlistment bonus for the associated job specialty. Such bonuses are provided when there is a need for manpower in a particular job specialty. Specialties provided reenlistment bonuses were coded as 1 and specialties not provided bonuses were coded as 0 in measuring this variable. The number of students trained per year was obtained directly from the course training plan.

In addition to manning needs, the difficulty of tasks performed in a job specialty was frequently mentioned by instructional systems design personnel and training managers as having a significant influence on the design of courses and on student performance. As a result, it seemed prudent to include an index of the difficulty of job tasks. Given the objectives of the

present effort, it seemed appropriate to use the occupational learning difficulty indices resulting from AFHRL occupational research as a measure of the variable. Information pertaining to the validity of this construct is provided elsewhere (Burtch et al., 1982; Weeks, Mumford, & Harding, 1985).

As well as the difficulty of the tasks being trained, nearly all interview groups mentioned a variety of other factors that influenced the difficulty level of technical training courses. One variable frequently mentioned was the degree of abstractness of the course training material. Unfortunately, no measure of this construct was readily available; however, this concept appeared to be of sufficent importance to warrant its inclusion in the model. Consequently, it was decided to obtain ratings of the degree of abstractness of course material. This was done by having five psychologists familiarize themselves with the plan of instruction, training plan, and a sample of course material for each course. They then used a 5-point rating scale to judge each course in terms of the degree to which the mastery of abstract principles and concepts was emphasized. An average of these ratings was then used to represent the abstractness of each course as a whole. For a sample of 48 courses, an interrater reliability (R_{kk}) of .88 was obtained for this index. In addition, the abstractness values assigned various courses tended to conform to generally accepted notions concerning course difficulty. For example, the precision measuring equipment course received a high rating, whereas the security and law enforcement courses were rated lower.

Another variable that was viewed by instructional systems design personnel and instructors as being critical to training outcomes was the reading difficulty of course materials. This was especially true in the more demanding training programs. Consequently, an attempt was made to assess the reading difficulty of course materials. For each course, one paragraph from each of five different course readings was randomly selected. Subsequently, the reading difficulty of each paragraph was assessed using an algorithm developed by Taylor, Sticht, Fox, and Ford (1973). This algorithm has been shown to exhibit reliabilities in the .90s. To compute the overall index of reading difficulty for each course, the average reading difficulty level of all five of the selected paragraphs was derived.

Another potential source of course difficulty identified in the interviews pertained to the diversity of course materials. It was pointed out that courses were more difficult when students were required to master a variety of material. This variable proved to be measurable on the basis of available course information. Because the units of instruction within each course reflect a unified body of material, a fully reliable index of diversity was derived simply by counting the number of units specified in the course POI.

One final course content variable that emerged in discussions with training personnel was the expected student attrition rate for the course. The expected attrition rate not only influences the number of students assigned to a course, but it was believed that it also influences a variety of decisions in course design, as well as training outcomes such as individual student attrition decisions. Thus, there seemed to be a need to obtain an adequate measure of this variable. This presented little difficulty because expected attrition rates are specified in the course training plan. Consequently, this information could be employed to provide a highly reliable measure of this construct.

For the most part, the course content variables outlined previously were those that the interview groups considered to have the greatest influence on student performance in initial-skills training. However, at least four course content variables mentioned in the interviews were not included in the modeling effort; these were student-equipment ratio, patterning of the academic day between lecture and discussion, swing shift versus day shift, and volunteer versus nonvolunteer instructors. The latter two variables were rejected because they

could not be quantified without extraordinary efforts. The other variables did not appear to have sufficient impact, on the basis of the interview data, to warrant their inclusion in the model.

The preceding discussion has outlined the course content, student input, and training outcome variables that were considered for inclusion in the modeling effort, along with potential measures of these variables. An overview of all variables and associated measures is presented in Table 1. The comprehensiveness of the interviews suggests that, for the most part, all major variables were included.

Sample Selection and Data Collection

Construction of a general model applicable to a variety of courses requires that a representative sample of technical training courses be examined for the purpose of model development and testing. Accordingly, it was decided that data would be obtained from a sample of 50 initial-skills courses. Forty of these courses were to be used in model development while the remaining 10 courses would be used for cross-validation. The courses in model development and cross-validation were selected by AFHRL in consultation with representatives of ATC and the Air Force Military Personnel Center. Selection of courses was based on several criteria such as:

1. The selected courses should be representative of all ATC initial-skills courses.

2. The selector aptitude composites for the courses should represent all four aptitude areas, but courses having dual selector composites should be excluded.

3. There should be adequate variance in the minimum aptitude requirements for the courses selected.

4. There should be adequate variance in the content of the courses.

5. Different ATC technical training centers should be represented.

6. Relatively high-cost courses should be included, as well as courses with high student flow.

7. Courses having classified training documents (e.g., POIs) should be excluded.

8. Recently modified courses should be excluded.

9. Courses having computer-assisted instruction (CAI) should be represented.

10. Courses associated with sortie-generating specialties should be represented.

Once the sample of courses had been identified, personnel and training data required for model development and cross-validation were collected. The student sampling strategy was relatively straightforward. For each course, existing data bases were employed to identify a minimum of 50 individuals who had been admitted to one of the five most recent training classes. Subsequently, all other trainees who had entered the course during the previous 6 months were identified. AFHRL supplied this information along with all relevant personnel information drawn from the PACE file. Visits were then made to Sheppard AFB, Chanute AFB, Lowry AFB, Keesler AFB, and Lackland AFB, where ARRO staff members reproduced the training records of all students selected for inclusion in the study. At the same time, for each course, the following training documents were obtained:

Table 1. Specification of Measures

	Measure	Source
Training Outcome Variables		
Quality of Student Performance	Average of end-of-block tests	Student Record of Training, ATC 156
SIA Time	Hours of special individual assistance (SIA)	Student Record of Training, ATC 156
Academic Counseling	Number of academic counseling sessions	Student Record of Training, ATC 156
Nonacademic Counseling	Number of nonacademic counseling sessions	Student Record of Training, ATC 156
Retraining Time	Number of hours of retraining	Student Record of Training, ATC 156
Academic Attrition	Percentage of student academic eliminations	Student Record of Training, ATC 156
Nonacademic Attrition	Percentage of student nonacademic eliminations	Student Record of Training, ATC 156
Student Input Variables		
Aptitude	Scores on selector aptitude composite of Armed Services Vocational Aptitude Battery	Personnel Data Files
Reading Level	Average score on the Air Force Reading Abilities Test	Student Record of Training, ATC 156
Academic Motivation	Number of difficult high school courses taken	Personnel Data Files
Simple Interest	Received guaranteed specialty	Personnel Data Files
Preference Interest	Received preferred specialty	Personnel Data Files
Educational Level	Highest educational level	Personnel Data Files
Educational Preparation	Recommended high school course prerequisites taken	Personnel Data Files
Age	Years from birth	Personnel Data Files
Course Content Variables		
Course Length	Number of total instructional hours	Plan of Instruction (POI)
Day Length	Length of instructional day (1 equals 8-hour day; 0 otherwise)	Training Plan
Student-Faculty Ratio	Number of students per instructor	Training Plan
Instructor Experience	Average months of instructor experience	Plan of Instruction (POI)
Instructor Quality	Average instructor performance evaluations	Course Supervisors
Aids in Use	Number of instructional aids divided by course length	Plan of Instruction (POI)
Hands-On Instruction	Hours of hands-on instruction divided by course length	Plan of Instruction (POI)
Amount of Feedback	Number of evaluations divided by course length	Plan of Instruction (POI)
Amount of Practice	Course length divided by number of units	Plan of Instruction (POI)
Reenlistment Bonus	1 if selective reenlistment bonus offered; otherwise 0	AFHRL
Yearly Student Flow	Number of students to be trained yearly	Training Plan
Occupational Difficulty	Overall learning difficulty of occupational tasks	AFHRL
Reading Difficulty	Average reading grade level of course materials	ARRO Staff
Abstract Knowledge	Average rating of abstract knowledge requirements	ARRO Staff
Expected Attrition	Expected proportion of students eliminated	Training Plan
Diversity	Number of units in course	Plan of Instruction (POI)

1. plan of instruction (POI),

2. course chart (CC),

3. training plan (TP),

4. specialty training standard (STS),

5. a sample of training materials,

6. number of months of instructional experience of instructors assigned to the course, and

7. the two most recent instructor evaluation checklists (ATC Form 281) for all instructors assigned to the course.

An overview of the data collected may be found in Table 2. As may be seen, a complete set of usable data was obtained for 48 of the 50 courses identified. The courses for which complete data could not be obtained were associated with AFS 42334, Aircraft Pneudraulic Systems Mechanic, and AFS 32637, Integrated Avionics Attack Control Systems Specialist. This resulted in the loss of one course from both the cross-validation and model-development samples. As a result, all personnel and training data collected for these courses were eliminated from the analyses. Nevertheless, as is shown in Table 2, the remaining model-development and cross-validation courses were quite diverse, with titles ranging from Carpentry Specialist and Financial Service Specialist to Precision Measuring Equipment Specialist and Jet Engine Mechanic. In all, eight courses were drawn from the technical training center (TTC) at Chanute AFB, 14 from the TTC at Sheppard AFB, 10 from the TTC at Lowry AFB, 14 from the TCC at Keesler AFB, and two from the Military Training Center at Lackland AFB. Because five of the six major ATC training centers were represented in the present effort, representation was considered adequate. Moreover, the selector aptitude composites associated with the selected courses represent all aptitude areas and the full range of minimum aptitude requirements. In sum, these observations suggest that the courses identified for model development and cross-validation provide a representative sample of all Air Force initial-skills courses.

For all courses combined, the student sample provided a total of 5,981 subjects for model development and cross-validation. All students in the sample entered training in 1983 or 1984 and had completed training by August 1984. The vast majority of the students were males; however, female students were included in proportion to their overall presence in the Air Force. Within the total sample, data for 5,091 students were to be used for model development, and data for 890 students were to be used in the cross-validation. There were no marked differences in the demographic characteristics of the student samples used for the model development and cross-validation.

Preliminary Analyses

Once the data had been collected and coded, preliminary data analyses were conducted. In these analyses, it was assumed that all course content variables could be applied to all students assigned to each course. Further, it was assumed that students with missing data for some variable would be omitted from only those analyses which involved that variable. Given these assumptions, the overall mean and standard deviation for each course content, student input, and training outcome variable were obtained in the total sample, the model-development sample, and the cross-validation sample. Subsequently, the mean and standard deviation of each student input, course content, and training outcome variable were obtained for each course.

Table 2. Demographic Information by Course and Training Center

	Specialty code	Sample[a]	Aptitude minimum	Total students	Males	Females	Year of training
Chanute technical training center							
Aircraft Environmental Systems Mechanic	42331	M	M30	93	90	3	83
Aircraft Fuel System Mechanic	42333	M	M35	64	58	6	83
Airframe Repair Specialist	42735	M	M35	73	66	7	83
Missle Maintenance Specialist	44330	M	M35	73	73	0	83
Special Vehicle Mechanic	47231	M	M30	62	62	0	83
Fire Protection Specialist	57130	M	G40	130	130	0	83
Aircraft Electrical Systems Specialist	42330	V	E40	49	44	5	83
Jet Engine Mechanic	42632	V	M30	186	162	24	83
Total Students				730	685	45	
Sheppard technical training center							
Aircraft Loadmaster	11430	M	M35	38	37	1	83
Telephone Switching Specialist	36231	M	E45	54	51	3	83
Cable Splicing Specialist	36131	M	M35	40	40	0	83
Tactical Aircraft Maintenance Specialist	43131	M	M35	39	38	1	82
Electrician	54230	M	M40	71	66	5	84
Carpentry Specialist	55230	M	M35	101	100	1	84
Financial Services Specialist	67232	M	A65	102	67	35	83
Medical Services Specialist	90230	M	G45	261	206	55	83
Surgical Services Specialist	90232	M	G45	95	74	21	83
Medical Administrative Specialist	90630	M	G45	136	92	44	83
Physical Therapy Specialist	91330	M	G45	57	40	17	83
Dental Assistant Specialist	98130	M	G45	139	98	41	83
Financial Management Specialist	67231	V	A65	102	65	37	83
Medical Laboratory Specialist	92430	V	G45	164	126	38	83
Total Students				1399	1100	299	
Lackland security specialist center							
Security Specialist	81130	M	G30	926	926	0	83
Law Enforcement Specialist	81132	M	G35	304	277	27	83
Total Students				1230	1203	27	

Table 2. (Concluded)

	Specialty code	Sample[a]	Aptitude minimum	Total students	Males	Females	Year of training
Lowry technical training center							
Continuous Photo Processing Specialist	23330	M	G45	90	73	17	83
Instrumentation Mechanic	31633	M	E65	42	40	2	82
Avionic Sensor Systems Specialist	32232	M	E70	34	33	1	83
Precision Measuring Equipment Specialist	32430	M	E65	136	129	7	83
Aerospace Ground Equipment Specialist	32630	M	E75	54	42	12	83
Computerized Test Station Specialist	32634	M	E65	20	20	0	83
Attack Control Systems Specialist	32636	M	E65	63	61	2	83
Munitions Systems Specialist	46130	M	M45	237	225	12	83
Materiel Facilities Specialist	64531	M	G30	158	142	16	83
Armament Systems Specialist	46230	V	M45	68	64	4	83
Total Students				902	829	73	
Keesler technical training center							
Command and Control Specialist	27430	M	G50	21	17	4	83
Wideband Communication Equipment Specialist	30430	M	E65	143	139	4	83
Electronic Computer Specialist	30534	M	E65	92	90	2	83
Telecommunications Control Specialist	30730	M	E65	81	75	6	84
Airborne Warning Systems Specialist	32832	M	E65	74	74	0	83
Electronic Warfare Systems Specialist	32833	M	E65	117	117	0	83
Computer Operator	51130	M	G40	152	202	50	83
Administration Specialist	70230	M	A35	417	301	116	83
Personnel Specialist	73230	M	A50	184	111	73	83
Personal Affairs Specialist	73231	M	A50	68	40	28	83
Ground Radio Operator	29333	V	A50	113	76	37	83
Aircraft Warning Radar Specialist	30332	V	E75	85	82	3	83
Navigation Systems Specialist	32831	V	E65	77	74	3	83
Computer Programming Specialist	51131	V	G55	46	41	5	83
Total Students				1720	1389	331	

[a]M - Course included in model-development sample; V - Course included in cross-validation sample.

After these preliminary descriptive analyses had been conducted, an attempt was made to establish the simple bivariate relationships among all variables. This was accomplished by intercorrelating scores on all of the variables being considered for inclusion in the model in the total sample, and then obtaining separate estimates of these relationships within the model-development and cross-validation samples. This basic descriptive information provided a framework for reviewing the initial conceptual model, and reevaluating initial conceptualizations of the relationships among the variables. This revision and refinement of the initial hypothetical model was a highly intuitive process carried out in a series of discussions with knowledgeable Air Force personnel.

Primary Analyses

Once an acceptable revision of the initial hypothetical model had been formulated, model development was undertaken. This was a relatively straightforward process in which the LISREL V program for the estimation of linear structural models was applied to the correlations obtained within the model-development sample (Joreskog & Sorbom, 1980). All analyses were carried out using an unweighted least squares procedure. Application of this strategy offered certain advantages in terms of cost and the robustness of parameter estimates, although it did prohibit obtaining estimates of the standard error of the path coefficients.

The LISREL V program operates by taking a series of specified causal relationships among the variables and generating parameter estimates that will maximize the amount of covariation in the observed data which can be accounted for by the hypothetical model. As well as allowing the user to specify causal paths between exogenous (i.e., independent) variables and endogenous (i.e., dependent) variables, LISREL V allows specification of causal paths among endogenous variables. In estimating these parameters, the LISREL V program can take into account correlations among observed or latent exogenous variables and endogenous variables, as well as correlated error terms among exogenous variables and correlated error terms among endogenous variables. In all analyses, correlation matrices were assumed to provide legitmate estimates to be included in the model.

Once these decisions had been made, it was possible to run the model through the LISREL V program. Initially, the goodness-of-fit test and the amount of residual variance unaccounted for by the model were examined. The multiple correlation coefficients (Rs) for the prediction of all training outcomes given the hypothesized causal relationships specified by the model were obtained, along with regression coefficients and standardized path coefficients specified by the causal relationships among the exogenous and endogenous variables and among the endogenous variables alone. Estimates of the total effect of each variable on all relevant dependent variables were also generated along with the requisite correlation matrices. It should be noted that these regression weights and path coefficients are not identical to Rs but rather, represent weights for prediction.

Once this model had been generated and the relevant data examined, an attempt was made to evaluate the predictive efficiency of the model. The regression coefficients specified in the foregoing analyses were used to predict training outcomes in the nine cross-validation courses, given knowledge of the course content variables for each course and average values for student input variables. The agreement between predicted training outcomes and the observed training outcomes for each of the nine courses then served as the basis for evaluating the predictive utility of the model. On the whole, the analyses described above seemed adequate for the development of an empirical model for use in predicting the impact of aptitude requirement adjustments on Air Force initial-skills training.

III. RESULTS

Descriptive Analyses

Table 3 presents means and standard deviations of scores on all of the student input, course content, and training outcome variables for the total sample, the model-development sample, and the cross-validation sample. These data were derived by aggregating over students or courses within each sample. The actual value for each student input, course content, and training outcome variable for each technical training course are provided in Appendices E, F, and G. With regard to student inputs, it should be noted that ASVAB scores for all students are based on 1944 norms. This fact is important for score interpretation because in October 1984, soon after data had been collected for this effort, a new set of norms based on a 1980 youth population began to be used for the derivation of ASVAB scores (Ree, Valentine, & Earles, 1985). Comparisons between the mean scores on the ASVAB aptitude composites for each sample and historical ASVAB data indicated that sample means are typical of those found in Air Force enlistee populations. Examination of Table 3 indicates that most trainees were approximately 20 years old and had completed high school. Additionally, they had taken one or two courses in high school that were considered to be desirable prerequisites for the specialties to which they were assigned. The interest measures indicate that roughly half of the trainees were guaranteed a particular job specialty and that most trainees received one of their preferred specialties. Typically, these trainees were able to read at an eleventh grade level, and had evidenced some academic achievement motivation with respect to the courses they took in high school.

On the whole, the means and the standard deviations of the various student input variables were remarkably similar for the model-development and cross-validation samples. However, it appears that the cross-validation sample consisted of students of somewhat higher quality. This was evidenced by consistently higher average scores on the ASVAB aptitude composites in the cross-validation sample. This result appears to indicate that the cross-validation sample was composed of courses associated with higher aptitude requirement minimums.

In reviewing the results obtained for the course content variables, a number of salient points should be noted. First, the resident technical training courses sampled were about 400 hours in length and, on the average, were divided into 49 units of instruction (diversity). Roughly half of the courses operated on an 8-hour instructional day, whereas the other half operated on a 6-plus-2-hour instructional day. Generally, one instructor was available for every nine students. Instructors tended to have roughly 2 1/2 years of training experience, and the quality of the instruction they provided was judged by instructor supervisors as being between good and satisfactory. Slightly less than half of the the total training time was devoted to hands-on instruction, while instructional aids were used on at least a daily basis and feedback in one form or another was provided once every 3 hours. On the average, training programs devoted 8.5 hours to each unit of instruction, and operated under an expected attrition rate of 9%. Of the courses selected for study, slightly less than half were associated with specialties having selective reenlistment bonuses. On the whole, most courses made only moderate demands with regard to the mastery of abstract principles although there were substantial differences in this variable across courses. The average reading grade level of training materials was 10.4, indicating that the material was quite appropriate for use with students having an 11.4 reading grade level. However, it should be recognized that this conclusion pertains only to training materials produced by ATC. Training materials produced by private vendors and technical orders were not included in the analysis. The average learning difficulty of the tasks performed in specialties associated with the courses sampled was typical of that found for most AFSs. It should be noted that the average yearly student flow for the courses was quite high in the total and model-development samples relative to the cross-validation sample. This result is due to the inclusion of a few high-flow courses, such as Security Specialist (AFS 81130), in the

Table 3. **Means and Standard Deviations of Variables**

	Total sample (N = 5,981)		Model-development sample (N = 5,091)		Cross-validation sample (N = 890)	
Student input variables[a]	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Mechanical	55.13	22.40	54.40	22.30	59.30	22.60
Administrative	63.16	19.50	62.70	19.50	65.80	19.70
General	65.28	16.90	64.70	16.80	68.60	17.30
Electronics	63.46	18.50	62.70	18.50	67.80	18.00
Reading Level	11.43	1.00	11.40	1.00	11.60	1.00
Academic Motivation	38.94	13.40	38.40	13.30	42.00	13.50
Simple Interest	1.41	.49	1.40	.49	1.50	.50
Preference Interest	4.42	.86	4.40	.87	4.50	.82
Educational Level	2.12	.45	2.10	.42	2.20	.56
Educational Preparation	1.65	.94	1.60	.87	1.90	1.10
Age	20.07	2.20	20.00	2.10	20.50	2.30
Course content variables[b]						
Course Length	420.73	309.30	386.30	302.20	569.90	297.70
Day Length	.49	.49	.46	.49	.62	.48
Student-Faculty Ratio	9.03	4.80	9.20	4.90	8.30	3.90
Instructor Experience	33.43	14.70	29.70	12.90	49.60	13.60
Instructor Quality	2.48	.16	2.50	.16	2.40	.13
Aids In Use	.27	.10	.27	.10	.28	.13
Hands-On Instruction	.40	.13	.41	.13	.37	.10
Amount of Feedback	.34	.12	.35	.13	.28	.06
Amount of Practice	8.49	3.10	8.60	3.00	8.00	3.80
Reenlistment Bonus	.46	.49	.42	.49	.61	.48
Yearly Student Flow	1852.33	2662.50	2204.90	2782.00	324.50	118.00
Occupational Difficulty	99.36	22.10	93.40	18.80	125.20	23.30
Reading Difficulty	10.98	.63	11.00	.67	10.90	.30
Abstract Knowledge	2.39	.98	2.20	.91	3.20	.93
Expected Attrition	.10	.03	.09	.03	.13	.02
Diversity	49.06	43.30	49.90	41.10	45.40	45.20
Training outcome variables[a]						
Quality of Student Performance	85.27	7.60	85.00	7.70	86.80	6.90
SIA Time	6.54	15.40	5.90	15.20	10.20	15.80
Academic Counseling	1.43	3.40	1.40	3.40	1.60	3.40
Nonacademic Counseling	.17	1.50	.19	1.60	.08	.86
Retraining	11.12	51.50	8.80	42.70	24.40	84.50
Academic Attrition	.03	.16	.02	.15	.05	.22
Nonacademic Attrition	.005	.06	.004	.06	.011	.03

[a]Statistics based on subject samples (indicated at top of page).

[b]Statistics based on course samples (Total Sample = 48 courses, Model-Development Sample = 39 courses, Cross-Validation Sample = 9 courses).

model-development sample but not in the cross-validation sample. This is evidenced by the sizable standard deviation associated with yearly student flow in the total and model-development samples but not the cross-validation sample.

In examining the similarities and differences among the means and standard deviations of the course content variables across the model-development and cross-validation samples, another interesting finding emerged. It was found that course length, expected attrition rates, abstract knowledge requirements, and occupational difficulty were all higher in the cross-validation sample than in the model-development sample. This confirmed the observation made with respect to the student input variables that, on the whole, the cross-validation courses are more difficult than the model-development courses.

Having reviewed the descriptive characteristics of the student input and course content variables, the results obtained for the training outcome variables will now be considered. It is apparent in Table 3 that the incidence of both academic and nonacademic attrition in the various technical training courses is extremely low. In the total sample, only 167 academic attritions and 24 nonacademic attritions occurred. It should be recognized that the infrequency of these outcomes makes prediction much more difficult. Academic and nonacademic counseling occurred far more frequently than did attrition. The average trainee could be expected to receive one and one-half academic counseling sessions, whereas one student in six could expect to receive nonacademic counseling. Given these academic and nonacademic attrition and counseling rates, it seems reasonable to conclude that academic concerns are far more likely to result in negative training outcomes than are nonacademic concerns such as motivation or attitude. Finally, it should be noted that the relatively large standard deviation associated with these variables may be attributed to the fact that only a few students received counseling or were eliminated from training.

Overall, the quality of student performance in the various courses was adequate. Given a range of passing grades of 70 to 100, most students obtained a grade of 85. SIA appeared to be employed frequently in remediating errors, such that the typical student accrued an additional 6.5 hours of one-on-one instruction. However, the magnitude of the standard deviation indicates that students in some courses received substantially more SIA than did others. Retraining hours, while quite high at a mean of 11.1 hours in the total sample, also appear to be associated with a few students who received substantial amounts of retraining. This conclusion is supported by the sizable standard deviation for this training outcome. Finally, it should be noted that the higher average attrition rates, retraining time, and SIA time observed in the cross-validation sample relative to the model-development sample suggest that the courses included in the cross-validation sample were somewhat more demanding than those found in the model-development sample.

Correlational Data

Revision and extension of the initial conceptual model was based on information obtained during the interviews and on statistical relationships found for all pairs of variables in the model-development sample. Consequently, a discussion of these relationships is in order. Bivariate correlations derived on the basis of data obtained from the model-development sample are presented in Table 4. Correlations derived on the basis of data obtained from the total sample and the cross-validation sample are presented in Appendices H and I.

Turning first to the interrelationships among the training outcome variables, the assessed quality of academic performance exhibited a pattern of negative relationships with all other training outcomes, as would be expected given the impact of performance on decisions related to counseling, retraining, and attrition. The strongest relationships with assessed quality were

Table 4. Intercorrelations of Student Input, Course Content, and Training Outcome Variables in the Model-Development Sample (5,091 students; 39 courses)

Variables[a]		SI-1	SI-2	SI-3	SI-4	SI-5	SI-6	SI-7	SI-8	SI-9	SI-10	SI-11	SI-12	CC-1	CC-2	CC-3	CC-4	CC-5	CC-6
SI-1	Aptitude Selector	1.00	.47	.48	.75	.64	.53	.35	-.21	-.15	.18	.08	.18	.25	-.26	-.14	-.04	.09	-.13
SI-2	Mechanical		1.00	.26	.47	.66	.42	.25	-.05	-.02	.09	.03	.16	.30	-.08	-.23	-.18	.15	.06
SI-3	Administrative			1.00	.44	.27	.35	.26	-.07	-.06	.15	.06	.10	.06	-.16	-.01	.09	.01	-.15
SI-4	General				1.00	.75	.67	.35	-.13	-.06	.19	.11	.18	.23	-.14	-.07	.00	.02	-.18
SI-5	Electronics					1.00	.52	.40	-.10	-.03	.17	.08	.16	.34	-.16	-.18	-.08	.10	-.06
SI-6	Reading Level						1.00	.25	-.08	-.02	.16	.10	.19	.18	-.10	-.06	-.02	.02	-.14
SI-7	Academic Motivation							1.00	-.08	-.06	.29	.22	.24	.17	-.15	-.04	.00	.07	-.05
SI-8	Simple Interest								1.00	.71	-.07	-.05	-.10	-.02	.17	.04	-.10	-.05	.08
SI-9	Preference Interest									1.00	-.07	-.02	-.04	.00	.13	.00	-.11	-.01	.04
SI-10	Educational Level										1.00	.06	.43	.07	-.08	-.03	.00	.03	-.07
SI-11	Educational Prep.											1.00	.06	.20	.42	.05	.05	-.07	-.07
SI-12	Age												1.00	.13	-.13	-.07	.00	.06	-.08
CC-1	Course Length													1.00	-.37	-.42	-.19	.48	.06
CC-2	Day Length														1.00	.42	.00	-.24	-.01
CC-3	Student-Faculty Ratio															1.00	.48	-.40	-.39
CC-4	Instructor Quality																1.00	.02	.11
CC-5	Instructor Experience																	1.00	.00
CC-6	Aids in Use																		1.00
CC-7	Hands-On Practice																		
CC-8	Amount of Feedback																		
CC-9	Practice																		
CC-10	Reenlistment Bonus																		
CC-11	Student Flow																		
CC-12	Occupational Difficulty																		
CC-13	Reading Difficulty																		
CC-14	Diversity																		
CC-15	Abstract Knowledge																		
CC-16	Expected Attrition																		
TO-1	Quality of Performance																		
TO-2	SIA Time																		
TO-3	Academic Counseling																		
TO-4	Nonacademic Counseling																		
TO-5	Retraining Time																		
TO-6	Academic Attrition																		
TO-7	Nonacademic Attrition																		

Table 4. (Concluded)

Variables[a]		CC-7	CC-8	CC-9	CC-10	CC-11	CC-12	CC-13	CC-14	CC-15	CC-16	TO-1	TO-2	TO-3	TO-4	TO-5	TO-6	TO-7
SI-1	Aptitude Selector	.21	.05	-.13	-.01	-.25	.03	.27	.27	.21	.19	.37	-.03	-.15	-.07	-.09	-.08	-.04
SI-2	Mechanical	-.09	-.07	-.04	.19	-.18	.34	.06	.30	.30	.19	.25	.03	-.09	-.03	-.04	-.05	-.02
SI-3	Administrative	-.14	.04	.07	-.07	-.13	-.12	.18	.07	.02	.04	.24	-.07	-.13	-.06	-.09	-.06	-.03
SI-4	General	-.23	-.01	-.11	.05	-.18	.05	.13	.26	.26	.12	.33	-.04	-.13	-.04	-.08	-.07	-.02
SI-5	Electronics	-.20	-.03	-.12	.14	-.17	.23	.16	.37	.35	.21	.32	.00	-.10	-.05	-.06	-.06	-.04
SI-6	Reading Level	-.18	-.04	-.06	.04	-.13	.05	.10	.19	.19	.12	.32	-.05	-.15	-.02	-.08	-.07	-.01
SI-7	Academic Motivation	-.1	1.00	-.08	.03	-.12	.07	.14	.20	.16	.13	.21	-.02	-.07	-.05	-.05	-.05	-.04
SI-8	Simple Interest	.08	-.16	.16	.17	.29	.02	-.05	-.08	-.11	-.01	-.11	-.04	.02	.02	.01	.02	.00
SI-9	Preference Interest	.00	-.13	.12	.12	.17	.04	-.02	-.03	-.02	-.05	-.08	-.06	.00	.0	1.00	.02	.00
SI-10	Educational Level	-.09	.00	-.03	.03	-.09	-.02	.08	.06	.05	.05	.15	-.02	-.04	-.03	-.01	-.04	-.03
SI-11	Educational Prep.	.05	.15	-.29	-.20	-.18	-.12	-.03	.02	.34	.00	.02	.12	-.04	.00	-.05	-.03	-.01
SI-12	Age	-.10	.00	-.08	-.02	-.16	.02	.14	.14	.13	.11	.16	.01	-.02	-.03	.00	.02	-.02
CC-1	Course Length	-.25	-.11	-.03	.19	-.28	.56	.90	.87	.58	-.66	.19	.14	.12	-.03	.07	.01	-.02
CC-2	Day Length	.04	-.02	.27	.13	.46	-.10	-.52	-.39	-.23	-.36	-.30	-.05	-.03	.07	.05	.00	.05
CC-3	Student-Faculty Ratio	.01	.07	.01	-.18	.26	-.55	-.30	-.36	-.20	-.29	-.21	-.0	1.00	.04	.07	.00	.02
CC-4	Instructor Quality	.07	.57	-.37	-.57	-.26	-.45	.16	-.10	.06	-.08	.10	.02	-.04	-.03	-.04	.00	.00
CC-5	Instructor Experience	-.24	.08	-.18	-.08	-.36	.48	.32	.47	.26	.15	.24	.05	.04	-.05	.03	.00	-.01
CC-6	Aids In Use	.56	.00	-.02	.34	.33	.23	.06	.10	.00	.02	.01	.11	.04	.00	.07	.02	-.04
CC-7	Hands-On Practice	1.00	-.08	.12	.14	.46	-.12	.07	-.27	-.13	.09	-.08	.12	.01	.02	.03	.02	-.01
CC-8	Amount of Feedback		1.00	-.40	-.41	-.40	-.16	.09	.09	-.06	-.22	.20	.00	-.04	-.03	.00	.00	-.01
CC-9	Practice			1.00	.30	.56	.09	-.30	-.37	-.34	.17	-.29	-.15	.02	.07	-.04	.00	.06
CC-10	Reenlistment Bonus				1.00	.52	.36	-.06	.13	.02	.14	-.19	.00	.10	-.06	.04	.00	.00
CC-11	Student Flow					1.00	-.12	-.26	-.42	-.45	-.16	-.32	-.20	.00	.08	-.0	1.00	.01
CC-12	Occupational Difficulty						1.00	.06	.54	.44	.46	.05	.13	.08	.00	.06	.0	1.00
CC-13	Reading Difficulty							1.00	.43	.33	.48	.29	.04	-.01	-.06	.02	.01	-.05
CC-14	Diversity								1.00	.63	.51	.25	.16	.00	-.04	.09	.02	-.03
CC-15	Abstract Knowledge									1.00	.49	.11	.32	.09	-.03	.03	.03	-.03
CC-16	Expected Attrition										1.00	.07	.16	.07	-.01	.03	.0	1.00
TO-1	Quality of Performance											1.00	-.09	-.27	-.19	-.14	-.17	-.07
TO-2	SIA Time												1.00	.23	.00	.10	.06	-.01
TO-3	Academic Counseling													1.00	.22	.49	.50	.05
TO-4	Nonacademic Counseling														1.00	.24	.19	.49
TO-5	Retraining Time															1.00	.63	.14
TO-6	Academic Attrition																1.00	.00
TO-7	Nonacademic Attrition																	1.00

[a]Student input variables are denoted by the abbreviation SI. Course content variables are denoted by the abbreviation CC, and training outcome variables are denoted by the abbreviation TO.

produced by academic and nonacademic counseling, respectively. Academic counseling, in turn, yielded strong positive relationships with academic attrition and retraining time, whereas academic attrition and retraining time in turn displayed a strong positive relationship. This result was expected because academic counseling necessarily precedes attrition or retraining decisions. Similarly, a strong positive relationship was obtained between nonacademic counseling and nonacademic attrition, and a moderate positive relationship was observed between academic and nonacademic counseling. As might be expected on the basis of the coding procedures used, academic and nonacademic attrition were not correlated. A surprising finding was that SIA time was not strongly related to any other training outcome variable except academic counseling. The weak relationships found for SIA time and other training outcomes may be attributed to the fact that SIA is used as a remediation technique and is related to other outcomes only to the extent that it reveals underlying problems which cause students to be referred for academic counseling.

The most striking relationships observed for training outcome variables was that final outcomes like counseling (nonacademic and academic) and attrition (nonacademic and academic) exhibited weak relationships with the antecedent student input and course content variables, whereas immediate outcomes such as assessed quality and SIA time displayed some moderate relationships with the antecedent student input and course content variables. This suggests that any effect student input and course content variables have on final outcome variables (i.e., counseling and attrition) is moderated by the immediate outcomes, SIA time and assessed quality of performance. Assessed quality of performance exhibited only moderate positive relationships with the ASVAB aptitude composites. However, such relationships were expected because correlational analyses were conducted by combining courses of widely varying difficulty. It was also found that age, academic motivation, and educational level exhibited a pattern of positive relationships with assessed quality of performance. As expected, motivation, maturity, and educational level enhance training performance. The weak negative relationships between assessed quality and the two interest measures are counter-intuitive and may reflect inadequacies in these measures. The absence of a relationship between educational preparation and assessed quality may be attributed to the moderating influence of other student input or course content variables.

Among the course content variables, both instructor quality and instructor experience were positively related to assessed quality of performance. This finding supports the notion that effective teaching enhances student performance. It was found that academic day length and student-faculty ratio were negatively related to assessed quality of performance. These results appear to support suggestions by interviewees that an 8-hour academic day is too much for students to handle, and that student performance decreases when instructors are burdened with too large a class to devote sufficient time to individual students. Amount of feedback was positively related to assessed quality of performance, supporting the intuitive notion that frequent feedback increases training performance. Amount of practice exhibited a negative relationship with assessed quality of performance. The reason for this unexpected result is not clear, but it could be due to the moderating effect of other variables. Student flow exhibited a negative relationship with assessed quality of performance. This result was expected because high-flow courses are often associated with specialties having low aptitude requirements and because high-flow courses often have poor student-faculty ratios. It was found that course length exhibited a moderate positive relationship with assessed quality of performance. This finding supports the notion that training performance improves when students are given more time to learn. It was surprising to find that course diversity, abstract knowledge, and reading difficulty exhibited a pattern of positive relationships with assessed quality of performance. However, this result might be attributed to the tendency for more demanding courses to receive higher aptitude students. Such a hypothesis is supported by the correlations between these same variables and the ASVAB aptitude composites.

Few strong correlations were obtained between SIA time and student input and course content variables. It was found that SIA time was positively related to course length, as might be expected since longer courses would provide greater opportunity for SIA. It was also found that SIA time was negatively related to student flow, as was expected given the fact that the instructional demands created by a large class would tend to decrease the likelihood of SIA. Abstract knowledge, occupational difficulty, diversity, and expected attrition all yielded positive relationships with SIA time. These relationships may indicate that SIA time is likely to be higher in more difficult training courses. Use of instructional aids and hands-on practice were also found to exhibit positive relationships with SIA time, perhaps because the use of aids and hands-on performance may provide an overt signal to instructors that could alert them to the need for SIA. Finally, it should be noted that SIA time was effectively unrelated to student input variables, suggesting that the effects of student attributes on SIA time may be moderated by the assessed quality of performance or course content variables.

In examining the interrelationships among student input variables, a number of interesting findings emerged. First, scores on the ASVAB aptitude composites displayed a pattern of positive interrelationships, which is due to the fact that some aptitude composites share common subtests. Similarly, the aptitude measures displayed positive relationships with reading level as measured by the AFRAT. Scores on all of the aptitude composites displayed a pattern of positive relationships with educational level, educational preparation, academic motivation, and age. Although these relationships were expected, given the tendency of aptitude to facilitate academic motivation, encourage education, and maximize time spent in school, it should be noted that the strength of these relationships did not indicate a one-to-one correspondence. Finally, it should be noted that although a strong positive relationship was observed between the two interest measures, both measures exhibited a pattern of weak negative relationships with measures of aptitude, academic motivation, educational level, educational preparation, and age. This unexpected finding may be interpreted as a side effect of the personnel allocation system wherein the more talented individuals are most in demand, and therefore may be more likely to be given assignments they did not expressly request.

In examining the correlations between student input and course content variables, only trivial relationships were found for the most part. However, these two classes of variables are not independent within the context of initial-skills training. Scores on the various aptitude measures and students' reading levels exhibited a pattern of positive relationships with course length, course reading difficulty, abstract knowledge requirements, diversity, and expected attrition rates. This pattern of results would seem to indicate that high-ability individuals are more likely to be assigned to specialties having demanding training programs.

Upon examination of the interrelationships among the various course content variables, a complex pattern of relationships emerged. It was found that occupational difficulty, course reading difficulty, diversity, abstract knowledge requirements, course length, and expected attrition displayed the strongest interrelationships of all course content variables. Due to the similarity of the variables, it seems reasonable to hypothesize that they represent a factor which reflects course subject-matter difficulty.

One course content variable that exhibited a conspicuous pattern of strong-to-moderate relationships was yearly student flow. Student flow was found to yield negative relationships with occupational difficulty as well as course reading difficulty, diversity, abstract knowledge, course length, and expected attrition. These results appear to indicate that relatively fewer students enter the more difficult training courses. The negative relationships between student flow and both instructor quality and instructor experience may be attributed to the difficulty of obtaining sufficient numbers of experienced, quality instructors when the class size is routinely large. The positive relationship between student flow and student-faculty ratio probably

reflects the influence of student flow on class size. The positive relationship between flow and academic day length suggests that the less difficult, high-flow courses would have longer academic training days. The positive relationships obtained between flow and both instructional aids and hands-on instruction may be due to the tendency for investment in training support to be economically more feasible when a large number of individuals are to be trained. Student flow was negatively related to feedback, suggesting that student evaluation may be less frequent when a large number of students must be trained. On the other hand, student flow was positively related to practice, indicating that high-flow courses typically devote more training hours to each unit of instruction. Flow also exhibited a strong positive relationship with reenlistment bonus, as was expected given that manning needs underlie both selective reenlistment bonuses and student flow. In summary, the large number of strong relationships between student flow and other course content variables indicate that student flow plays a central role in the design of training courses.

Although practice yielded a strong positive relationship with flow, it exhibited a substantial negative relationship with feedback. The negative relationship with feedback was expected in view of the fact that feedback in the form of progress checks, performance tests, or sampling written tests are required by instructional unit. The shorter these units over the duration of the course, the greater the feedback. Practice was positively related to instructional day length since a longer instructional day provides for more practice per unit of instruction. It was found that instructor quality and instructor experience were positively related to practice and negatively related to feedback, perhaps because with long instructional units and limited feedback, there is less need for experienced, quality instructors. Confirming this hypothesis, feedback was found to be strongly related to instructor quality. It was also found that neither feedback nor practice produced a systematic pattern of relationships with course subject-matter difficulty indices, such as the reading difficulty of course materials.

Frequency of use of instructional aids was negatively related to student-faculty ratio. This finding may be attributed to the fact that high student-faculty ratios may limit the amount of instructor supervision that can be devoted to the use of aids. The use of aids was highly correlated with hands-on practice. This relationship was not surprising in view of the manner in which the instructional aids variable was defined and measured.

No systematic relationship was found between instructor quality and instructor experience; however, instructor experience was related to the occupational difficulty and indices of course subject-matter difficulty. Apparently, more experienced instructors are assigned to the more difficult courses. Both instructor quality and instructor experience were negatively related to student-faculty ratio. This result may indicate that difficult courses to which more experienced instructors are assigned are more likely to have fewer students per class. The appropriateness of this interpretation is supported by the negative correlation between instructor experience and instructional day length which also appears to be influenced by student flow. It should also be noted that student-faculty ratio and day length were positively related, perhaps due to the influence of student flow. Finally, both student-faculty ratio and day length were inversely related to occupational difficulty and indices of course subject-matter difficulty, perhaps because longer instructional days and larger classes are less likely to be appropriate as the difficulty of the training material increases.

Model Refinement

Earlier in this report, a rather simple conceptual model of the relationship among student inputs, course content variables, and training outcomes was presented. However, until the variables within each of these categories had been specified and interrelated, it was difficult to specify the model in greater detail. Having examined these relationships, it became possible

to construct a more detailed conceptual model of the relationships among the student inputs, course content variables, and training outcomes. Because this elaboration of the conceptual model is a critical step in the approach being followed in the present effort, this refinement of the conceptual model in relation to the intercorrelations among the student input, course content, and training outcome variables will be presented in some detail.

As noted earlier, academic counseling, nonacademic counseling, retraining, academic attrition, and nonacademic attrition consistently exhibited weak relationships with student input and course content variables, whereas assessed quality of performance and SIA time exhibited some moderate relationship with student input and course content variables. This observation suggested that the effect of student input and course content variables on training outcomes must operate through the assessed quality of student performance and SIA time. Moreover, the observed correlations support the common-sense notion that assessed quality of performance has a direct causal impact on both academic counseling and nonacademic counseling, while SIA time has a direct causal impact only on academic counseling. Further, it seems reasonable to assume that assessed quality of performance would have a direct causal impact on SIA time, although it is not expected that this effect is strong in view of the weak relationship between these variables.

Given this conceptualization of the immediate training outcomes, academic counseling and nonacademic counseling must be viewed as moderating the relationship between assessed quality and distal training outcomes such as retraining and attrition. This seems well justified because interview data indicated that either academic or nonacademic counseling necessarily precedes student elimination and retraining decisions. Thus, academic counseling was viewed as having a direct causal impact on academic attrition and retraining while nonacademic counseling was held to have a direct causal impact on nonacademic attrition. Because the interviewees also reported that frequent retraining usually led to academic attrition and because retraining and academic attrition were highly correlated, it was held that retraining would have a direct causal impact on academic attrition. It was also assumed that academic outcomes such as retraining and academic attrition would have no direct causal effect on nonacademic attrition. This assumption seems appropriate in view of the observed relationships and interview data which indicated that retraining was an academic action unrelated to nonacademic issues. However, it was held that academic counseling might have a direct causal impact on nonacademic counseling. This hypothesis was in part based on the observed pattern of relationships, and in part on the assumption that academic counseling might occasionally uncover nonacademic problems.

The preceding discussion specified hypotheses concerning the structure of the relationships among training outcomes. At this point, it is appropriate to turn to the expected relationships between the student input and training outcome variables. At the risk of introducing specification error, it was decided that the two vocational interest measures should not be included in the refined model. This decision was based on the ambiguity pertaining to the validity of the interest measures and the unexplained negative correlations between the interest measures and assessed quality of performance. Once this decision had been made, the pattern of the observed relationships between student inputs and training outcomes suggested that all of the remaining student input variables, (e.g., aptitude, reading level, academic motivation, educational level, educational preparation, and age) should be assumed to have direct impacts on assessed quality of student performance. Based on the observed weak relationships between student input variables and SIA, direct impacts on SIA time were not assumed. Rather, it was held that any impact student inputs had on SIA time was moderated through assessed quality of student performance or the course content variables.

Having specified the relationships among the student input and the training outcome variables, attention will now turn to the relationships specified for the course content variables. In the preceding discussion, it was suggested that student flow and course subject-matter difficulty were prime determinants of the relationships observed among course

content variables, such as student-faculty ratio and instructional day length. When this observation is coupled with the fact that training must consider the learning difficulty of occupational tasks, it appears reasonable to assert that training is driven by the difficulty of occupational tasks, the difficulty of course subject matter, and manpower requirements.

Although occupational difficulty could be measured directly, manpower requirements and course subject-matter difficulty represented latent variables that were defined through observed variables. The high correlation found between student flow and reenlistment bonus suggested that manpower requirements should be defined by these two variables. Given the pattern of correlations discussed earlier, it seemed that course subject-matter difficulty could be defined by the reading difficulty of course materials, the diversity of course materials, abstract knowledge requirements, expected attrition rates, and course length. However, it was held that only the former four variables would be used to define subject-matter difficulty since course length is reasonably considered an outcome of course subject-matter difficulty.

According to this conceptualization, course subject-matter difficulty, occupational difficulty, and manpower requirements were held to be the three fundamental or primal variables affecting training design. These variables were assumed to be correlated with each other. Also, these three primal variables were held to determine lower-order course variables, such as instructional day length and student-faculty ratio. Thus, course length, day length, student-faculty ratio, instructor quality, instructor experience, use of aids, hands-on practice, feedback, and practice were held to be determined by these three variables. However, based on the observed correlations, it was decided that instructional aids and hands-on practice should be combined into a latent variable representing instructional support, whereas feedback and practice should be combined into a latent variable representing feedback intensity.

Feedback intensity, instructional support, instructor experience, instructor quality, student-faculty ratio, day length, and course length were all assumed to be capable of having a direct causal impact on both the assessed quality of student performance and SIA time. The direct causal relationships with SIA time were postulated for these course variables, unlike the student inputs, because it was felt that course content variables such as course length or day length could affect the feasibility of SIA time regardless of performance. Further, it was assumed that independent of the effects of the various course variables on quality of performance, subject-matter difficulty, occupational difficulty, and manpower requirements might also have a direct causal impact on both assessed quality of performance and SIA time.

A schematic representation of the refined model is presented in Figure 3. As may be seen, the student input variables are assumed to be intercorrelated and have a direct causal impact on the assessed quality of performance. Course subject-matter difficulty, occupational difficulty, and manpower requirements are assumed to have a direct causal impact on all other course variables as well as on SIA time and the assessed quality of performance. Finally, all lower-order course variables, such as day length or student-faculty ratio, are assumed to have a direct causal impact on both the assessed quality of performance and SIA time.

The causal paths above the course parameters reflect the hypothesized effects of the three primal variables in order from left to right, while the causal paths below the course parameters reflect their effects on quality of performance and SIA time, respectively. Finally, the diagram shows that assessed quality of performance and SIA time determine all other training outcomes when moderated through academic and nonacademic counseling.

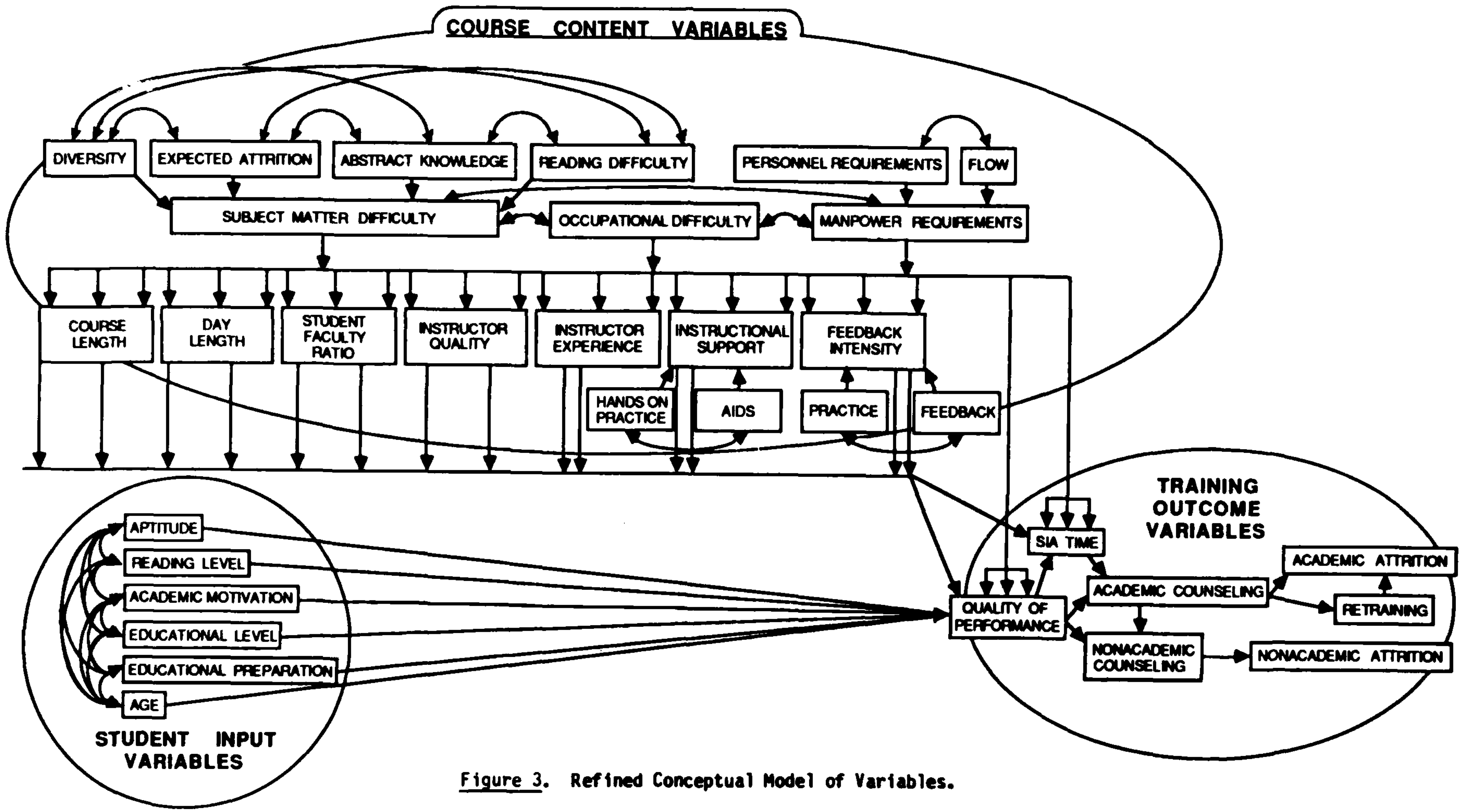

Figure 3. Refined Conceptual Model of Variables.

Modeling Results

When the refined model was analyzed by LISREL V, it was found to provide an excellent fit to the observed relationships among the student input, course content, and training outcome variables within the model-development sample. Overall, it was found that the model yielded a goodness-of-fit index of .59, and a residual of .19. This goodness-of-fit index indicates that the refined model provided an unusually close fit to the observed data. This was confirmed by the residual term, which indicated that only 19% of the variance in the relationships among the three classes of variables could not be accounted for by the hypothetical model.

Evidence of the predictive power of the model may be obtained by considering the Rs generated by the model against each of the dependent variables. These data are presented in Table 5 and broken down with respect to whether the dependent variable was a training outcome measure or a predicted course variable. For the training outcome variables, the model yielded an R of .75 against assessed quality of performance. Multiple correlation coefficients of .60 and .50 were obtained against academic and nonacademic counseling, respectively; retraining time, academic attrition, and nonacademic attrition produced Rs of .76, .83, and .59, respectively. Overall, this pattern of results indicates excellent prediction of training outcomes, with academic outcome variables being somewhat better predicted than nonacademic outcomes such as nonacademic counseling and nonacademic attrition. The weakest prediction of a training outcome variable was obtained for SIA time, which yielded an R of .35. Apparently, SIA time represents a somewhat unique variable among the training outcomes.

Table 5. **Multiple Rs and R^2s for Training Outcome and Course Content Variables**

	R	R^2
Training Outcome Variables		
Assessed Quality of Performance	.75	.54
SIA Time	.35	.12
Academic Counseling	.60	.36
Nonacademic Counseling	.50	.25
Retraining Time	.76	.59
Academic Attrition	.83	.70
Nonacademic Attrition	.59	.35
Predicted Course Variables		
Course Length	.86	.75
Day Length	.60	.36
Student-Faculty Ratio	.62	.38
Instructor Quality	.58	.34
Instructor Experience	.60	.36
Instructional Support	.54	.30
Feedback Intensity	.68	.47

For the course variables that were held to be determined by course subject-matter difficulty, occupational difficulty, and manpower requirements, a similar pattern of results was obtained. These three variables yielded Rs against course length, instructional day length, student-faculty ratio, instructor quality, instructor experience, instructional support, and feedback intensity of .86, .60, .62, .58, .60, .54, and .68, respectively. Overall, the magnitude of these Rs indicates that an optimal combination of subject-matter difficulty, occupational difficulty, and manpower requirements did an excellent job of predicting the lower-order course variables. This

is an important finding because it suggests that it is fully appropriate to conceive of training as being driven by course subject-matter difficulty, the difficulty of occupational tasks, and manpower requirements.

The foregoing results indicated that the refined model was capable of accounting for the relationships observed among the student input, course content, and training outcome variables, as well as yielding excellent prediction of training outcomes. Given this observation, it would seem appropriate to examine the nature and magnitude of the standardized path coefficients generated by the LISREL V program in optimizing regeneration of the variance-covariance matrix. The standardized path coefficients generated by the LISREL V program are presented in Figure 4. A standardized path coefficient represents the unique effects of an independent variable on a dependent variable when both are expressed in standard score form. It can be interpreted as the magnitude of change in the specified dependent variable given a one-unit change in the independent variable. For example, in Figure 4, the standardized path coefficient of .16, occurring above the arrow connecting aptitude with quality of performance, indicates that an increase in average quality of performance (dependent variable) of 16/100ths of a standard score unit would be expected to follow an increase in average aptitude (independent variable) of 1 unit, when all other independent variables are held constant.

Inspection of Figure 4 indicates that the student input variables have substantial effects on assessed quality of student performance. The most powerful effects were generated by aptitude (.16), reading level (.16), and academic motivation (.14). These results suggest that intellectual ability and motivation to achieve are prime determinants of training performance. However, sizable effects were also produced by age (.11) and educational level (.12), indicating that maturity and educational exposure both have independent causal effects on the quality of student performance. The weakest path coefficient produced by the various student input variables was a coefficient of .07 associated with educational preparation. This suggests that although specific educational preparation may contribute to performance, in a well-designed training program it does not have a particularly strong influence.

A number of interesting findings emerged among the course content variables. In defining course subject-matter difficulty, it appears that abstract knowledge requirements are the single best indicator of this construct, although sizable coefficients were also obtained for reading difficulty, course diversity, and expected attrition rates, indicating that all these variables must be considered for optimal definition of the construct. Similarly, in defining manpower requirements, both selective reenlistment bonus and yearly student flow yielded sizable coefficients. However, as indicated by the substantially greater magnitude of its standarized path coefficient, yearly student flow appears to be a more appropriate index of manpower requirements. Manpower requirements and course subject-matter difficulty proved to be negatively related, as was expected from the correlational data. Moreover, course subject-matter difficulty was positively related to occupational difficulty, apparently because the difficulty of a training program reflects the difficulty of job tasks. Occupational difficulty, however, was positively related to manpower requirements, unlike course subject-matter difficulty. These results might be attributed to a greater civilian demand for individuals trained in more difficult occupations, and the limitations that difficulty of a training program places on student flow.

In examining how course subject-matter difficulty, occupational difficulty, and manpower requirements determined lower-order course variables, a number of interesting findings emerged. It was found that course length was determined primarily by occupational difficulty (.40) and subject-matter difficulty (.58), rather than by manpower requirements (.02). This finding could be expected in a system where individuals must be trained to a constant standard of performance regardless of manpower requirements. On the other hand, it was found that instructional day length tended to increase with increasing manpower requirements (.36) and decrease with

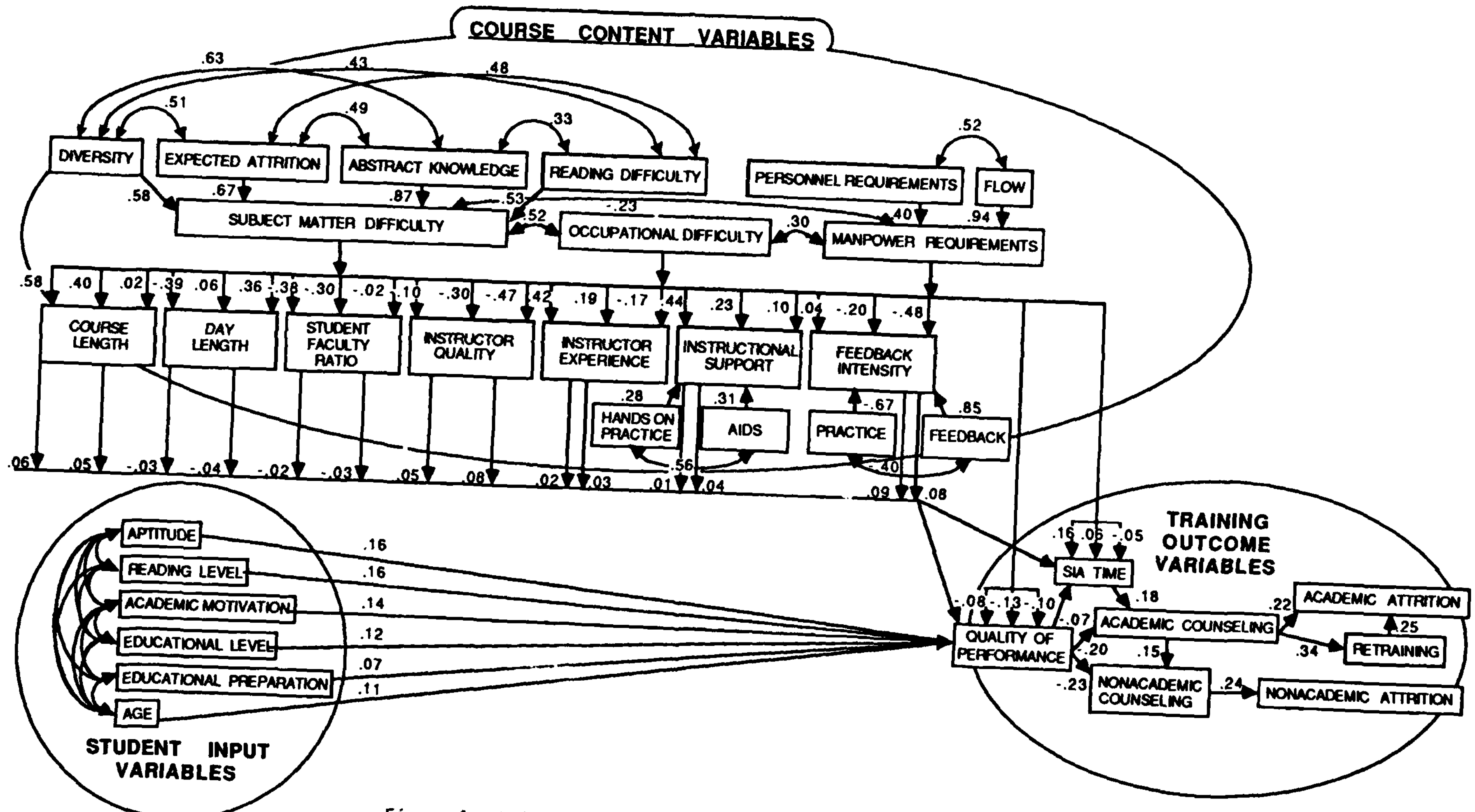

Figure 4. Refined Model with Standardized Path Coefficients.

increasing course subject-matter difficulty (-.39). This set of path coefficients appears to support the hypothesis that an 8-hour instructional day is used as one means of accommodating greater manpower needs, but that its use in difficult courses will be offset by the tendency of a longer instructional day to overload students with information.

Student-faculty ratio was found to be negatively related to both subject-matter difficulty (-.38) and occupational difficulty (-.30), while it was virtually unrelated to manpower requirements (-.02). Thus, it appears that the number of students per instructor is primarily due to the difficulty of the job and course subject matter rather than manning needs. Instructor quality was found to be negatively related to subject-matter difficulty (-.10), occupational difficulty (-.30), and manpower requirements (-.47). Apparently, a high quality of instruction is less feasible when the class size is large and the course material is difficult to teach. On the other hand, instructor experience was found to be positively related to subject-matter difficulty (.42) and occupational difficulty (.19). These results confirmed the previous hypothesis that more difficult courses require and are typically assigned to more experienced instructors. However, it was also found that instructor experience tended to be limited by manpower requirements (-.17), indicating that when need is high, it is more difficult to obtain highly experienced instructors.

Feedback intensity was conceptually defined by the amount of feedback occurring in a course and the amount of practice provided. This construct was confirmed by the relationship of feedback intensity with amount of feedback (.85) and practice (-.67). Feedback intensity was not influenced by course subject-matter difficulty (.04); however, it tended to be limited by both occupational difficulty (-.20) and manpower requirements (-.48). These negative effects might be attributed to the fact that it is more difficult for instructors to provide frequent feedback concerning performance on difficult tasks and to the fact that a large number of students tends to restrict the amount of feedback that can be provided.

As defined in the refined model, instructional support was considered to be a function of the number of instructional aids used and the amount of hands-on practice provided. This hypothesis was confirmed by the coefficient of .28 obtained for hands-on practice and the coefficient of .31 obtained for the number of aids in use. Although the magnitude of these coefficients suggests that this latent variable was not as well defined as the preceding latent variables, a consistent and interpretable pattern of path coefficients for this construct was generated by subject-matter difficulty (.44), occupational difficulty (.23), and manpower requirements (.10). As might be expected, instructional support is most likely to occur when course training materials and job tasks are difficult. Furthermore, instructional support tends to be employed more frequently when student flow is sufficiently high to result in a payoff from its development.

In addition to the above interrelationships, it was found that the course content variables were capable of determining training outcomes. All three of the primal course content variables defined by subject-matter difficulty (-.08), occupational difficulty (-.13), and manpower requirements (-.10) had a direct causal impact on the assessed quality of student performance. These effects indicate that difficult courses, difficult job tasks, and requirements to train large numbers of students will tend to restrict the quality of student performance. It was also found that SIA time was slightly influenced by subject-matter difficulty (.16), by occupational difficulty (.06), and by manpower requirements (-.05). In fact, subject-matter difficulty was the prime determinant of SIA time, as was expected, since more difficult courses should cause progress check failure and therefore greater SIA time. Alternatively, manpower requirements had a negative effect on SIA time because large classes tend to restrict the amount of SIA that can be provided.

When the effects of these three primal variables were controlled, it was found that certain lower-order course variables could also have an impact on the assessed quality of student

performance and SIA time. In keeping with the interview reports, it was found that feedback intensity had the greatest impact on the quality of performance (.09) and SIA time (.08). The former relationship may reflect the generally recognized facilitative effects of feedback on performance, whereas the latter relationship may indicate that feedback can serve as an indicator of the need for SIA. As expected, instructor quality was found to have positive effects on the quality of performance (.05) and SIA time (.08). These results suggested that, good instruction enhances student performance and good instructors may be more likely to provide SIA time. Finally, as expected, course length had moderate positive impacts on both SIA time (.05) and the quality of student performance (.06).

The path coefficients obtained for instructional day length, student-faculty ratio, instructional support, and instructor experience were not especially powerful when the effects of course subject-matter difficulty, occupational difficulty, and manpower requirements were partialed out. However, both day length and student-faculty ratio had minor negative effects on assessed quality of performance and SIA time, supporting the information overload hypothesis and the notion that student performance had a slight tendency to decrease as class size increased. Instructor experience, on the other hand, tended to have minor positive effects on both the quality of performance and SIA time, indicating that experienced instructors facilitate quality performance and tend to provide more SIA. Finally, instructional support produced a minor positive effect for SIA time, perhaps because such support provides signals concerning the need for SIA.

As indicated in the preceding discussion, the assessed quality of student performance had substantial effects on all relevant training outcomes, especially academic counseling (-.20) and nonacademic counseling (-.23). Academic counseling, in turn, had a positive effect on academic attrition (.22) and retraining (.34), while nonacademic counseling had a positive effect on nonacademic attrition (.24). These results confirm the earlier hypothesis that counseling moderates the relationship between quality of performance and subsequent training outcomes such as retraining and attrition. Further, a path coefficient between academic and nonacademic counseling (.15) supported the proposition that academic counseling tends to reveal nonacademic problems. A path coefficient between retraining time and academic attrition (.25) was also found in this analysis. Thus, high retraining time appears to be an antecedent of attrition, as was indicated by the interview data.

The assessed quality of performance exhibited a weak causal impact on SIA time (-.07). This suggests that poor performance might have some effect on SIA time, but that the difficulty of the course material still appears to be the prime determinant. Finally, as expected, SIA time had a direct impact (.18) on academic counseling. This result confirms the expectation that repeated SIA sessions tend to serve as a signal for academic problems.

Overall, the foregoing discussion of the standardized path coefficients resulting from the analysis indicates that the refined model yields a highly meaningful and interpretable set of interrelationships. This provides compelling evidence for the validity of the model when coupled with the observed residual, goodness-of-fit test, and Rs. The refined model, with regression coefficients and total effects, is presented without further discussion in Appendices J and K, respectively.

One last topic that must be addressed concerns one of the basic assumptions of path modeling. The independence of errors associated with variable measurement is one of the more important assumptions associated with this analytical technique. Evaluation of correlations between the error terms for the course variables, as well as correlations between the error terms of the course variables and training outcome variables, served as a basis of determining the tenability of this assumption. These correlation coefficients are provided in Appendices L and M, respectively. Inspection of these data indicates that the error terms of the course

parameters and the outcome variables were not strongly related, and that the error terms among the course parameters themselves were effectively independent. Correlations between the error terms for the training outcome variables which are presented in Appendix N indicated a pattern which conforms to the formal path model. For instance, errors in the measurement of the assessed quality of performance were slightly related to errors associated with other training outcomes. However, this result was expected because assessed quality of performance is the basis for decisions associated with other training outcomes such as retraining and attrition. Similarly, measurement errors for academic counseling, which plays a pivotal role in these training outcome decisions, were correlated with all other variables. Thus, the pattern of relationships among error terms is consistent with the overall model.

Cross-Validation

The preceding discussion has demonstrated that the refined model provides a meaningful and interpretable description of the relationships among student input, course content, and training outcome variables and that it accounts for much of the variance in training outcomes. Although these results clearly suggest the predictive utility of the model, the questions that arise at this point are whether accurate predictions will result when courses not employed in model development are examined, and most importantly, whether the refined model is sufficiently representative to be effectively employed in making predictions for a diverse set of courses.

To answer these questions, a cross-validation analysis compatible with the path-analytic procedures was carried out. This analysis entailed obtaining standard scores on the student input and course content variables for each of nine courses held for cross-validation and entering values for the student input and course content variables for each course into the relevant regression equations to obtain standard score predictions for the seven training outcomes. These standard score predictions were then converted to raw score predictions. Once this information was obtained, it was directly compared to the raw scores and standard scores actually observed for the cross-validation courses for each training outcome.

It should be noted that when generating training outcome predictions for each course, the nature of the model dictated the application of a certain strategy. Distal training outcomes are not predicted directly from knowledge of student input or course content variables. The refined model holds that distal training outcomes, such as attrition and retraining, are dependent on the intervening counseling process and assessed quality of performance. Thus, predictions of the assessed quality of performance and SIA time, which issued directly from knowledge of student input and course content variables, were used in deriving predictions of academic and nonacademic counseling rates. In turn, the predicted academic and nonacademic counseling rates were used in conjunction with the appropriate regression weights to generate predictions of academic attrition, nonacademic attrition, and retraining time. Although this procedure was in keeping with the design of the model and its intended application, it should be borne in mind that due to the possibility of cumulative prediction error, it constitutes a conservative test of the predictive accuracy of the model with respect to the distal training outcomes of academic counseling, nonacademic counseling, retraining time, academic attrition, and nonacademic attrition.

Table 6 displays observed and predicted scores in both raw score and standard score form for all training outcomes for each of the nine cross-validation courses. As may be seen, predictions of assessed quality of performance, which was expressed as an average final course grade, approximated the observed values. Across the nine courses, there was an average absolute difference between predicted and observed raw scores of 2.34 points. It is noteworthy that the model predicted average final school grade about equally well for all nine courses. In fact, the

Table 6. Predicted and Observed Training Outcomes

Course	Assessed quality of performance				SIA time				Academic counseling			
	Raw scores		Standard scores		Raw scores		Standard scores		Raw scores		Standard scores	
	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED
Aircraft Electrical Sys. Spec. (42330)	90.0	86.5	.64	.16	3.8	10.8	-.13	.32	2.3	1.5	.26	.04
Jet Engine Mechanic (42632)	85.0	81.5	.00	-.45	4.6	10.7	-.08	.32	.7	1.4	-.20	.01
Financial Management Spec. (67231)	86.4	88.2	.19	.41	10.3	5.9	.28	.00	1.3	1.2	-.03	-.07
Medical Laboratory Spec. (92430)	84.9	89.5	.00	.59	26.4	10.1	1.21	.28	2.5	1.2	.32	-.05
Armament Systems Spec. (46230)	85.9	85.3	.11	.05	1.5	8.1	-.28	.15	.8	1.5	-.15	.03
Ground Radio Operator (29333)	86.6	86.6	.20	.20	12.5	6.0	.43	.01	2.8	1.3	.24	.29
Aircraft Warning Radar Spec. (30332)	89.5	88.3	.58	.43	13.1	10.9	.32	.48	2.1	1.5	.20	.20
Navigation Systems Spec. (32831)	90.5	88.1	.74	.39	3.3	10.6	-.17	.33	1.4	1.4	.00	.00
Computer Programming Spec. (51131)	87.4	90.4	.37	.71	5.8	10.0	-.01	.27	.6	1.1	-.23	-.07
Average Absolute Difference[a]	2.34		.331		6.83		.421		.67		.182	

Course	Nonacademic counseling				Retraining time				Academic attrition				Nonacademic attrition			
	Raw scores		Standard scores		Raw scores		Standard scores		Raw scores		Standard scores		Raw scores		Standard scores	
	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED	OBS	PRED
Aircraft Electrical Sys. Spec. (42330)	.10	.13	-.06	-.03	8.8	9.3	.00	.01	.02	.02	.00	.013	.000	.003	-.07	.021
Jet Engine Mechanic (42632)	.16	.26	-.01	.08	16.5	10.5	.18	.04	.03	.02	.06	.011	.010	.006	.10	.069
Financial Management Spec. (67231)	.05	.05	-.09	-.09	25.0	7.7	.37	-.02	.06	.02	.26	-.014	.000	.002	-.07	-.023
Medical Laboratory Spec. (92430)	.11	.00	-.05	-.12	53.7	8.0	1.00	-.02	.11	.01	.60	-.017	.000	.002	-.07	-.032
Armament Systems Spec. (46230)	.07	.14	-.08	-.01	14.9	9.3	.14	.01	.05	.02	.20	.010	.000	.003	-.07	-.001
Ground Radio Operator (29333)	.03	.10	-.10	-.05	28.0	8.3	.44	-.01	.06	.02	.26	-.011	.000	.003	-.07	-.012
Aircraft Warning Radar Spec. (30332)	.06	.06	-.08	-.08	13.9	9.1	.11	.01	.04	.02	.13	.015	.000	.002	-.07	-.022
Navigation Systems Spec. (32831)	.05	.08	-.09	-.07	14.0	9.0	.12	.01	.01	.02	-.06	.003	.000	.002	-.07	-.014
Computer Programming Spec. (51131)	.02	.00	-.10	-.14	9.2	7.7	.02	-.02	.00	.02	-.12	-.024	.000	.001	-.07	-.037
Average Absolute Difference[a]	.64		.05		11.62		.27		.028		.172		.002		.031	

[a]Observed versus Predicted Scores.

largest difference observed between predicted and observed raw scores on this measure was only 4.6 points.

The model's accuracy in predicting assessed quality of performance was not matched with regard to SIA time. The overall difference between predicted and observed raw scores for the nine cross-validation courses was 6.83 hours. These results were expected, given that SIA time produced the smallest R observed in the present investigation.

Table 6 also presents the results obtained in the cross-validation analysis for academic counseling and nonacademic counseling. For the nine courses, the average difference between observed and predicted raw scores was .67 for academic counseling, and .64 for the nonacademic counseling. The largest difference in observed and predicted raw scores was .11 for nonacademic counseling and 1.5 for academic counseling. Given the relative infrequency of nonacademic counseling, it was surprising that the model provided more accurate predictions for it than for academic counseling. However, this result might be attributed to the fact that within the model, cumulative errors carried over from SIA time would affect predictions of academic counseling more than they would predictions of nonacademic counseling.

With respect to retraining time, the average difference obtained between predicted and observed raw scores was 11.6. Predictive accuracy held across courses, with the exception of those that had unusally high retraining times. The results obtained for academic attrition indicated that the average difference between predicted and observed attrition rates was .03.

As was noted earlier, the nonacademic attrition rate was extremely low. In fact, for the nine cross-validation courses, only one student was eliminated for nonacademic reasons. This nonacademic student elimination occurred in the Jet Engine Mechanic course. Surprisingly, the highest predicted nonacademic attrition rate was for this course, and in fact, it was the only predicted value which was not extremely close to zero.

Clearly, the predicted outcomes were reasonably consistent with the actual values. However, the cross-validation study does not fully demonstrate generalizability of results across courses, time, and both courses and time. Therefore, we think it best to view the present model as a reasonably good first approximation to the complex relationships involved in initial-skills training. As additional data become available and as personnel and training managers gain experience with the working of the system, it would be appropriate to revisit empirically the accuracy of the model's predictions for the same courses at different points in time, for different courses, and for different courses at different points in time.

IV. DISCUSSION

Findings

The principal concern giving rise to this work was the need for some technique that would allow estimation of the effects of aptitude requirement adjustments on technical training outcomes prior to actually making such adjustments. Because the model described above has been shown to be quite stable and to have substantial predictive power, it appears to provide a viable basis for drawing general conclusions concerning the relationship between aptitude and training outcomes.

The most straightforward conclusion indicated by the content of the refined model is that aptitude is clearly a prime determinant of training outcomes. This was attested to by the fact that aptitude yielded one of the most powerful path coefficients against assessed quality of student performance. Nevertheless, this observation should not be taken as indicating that

aptitude is the only determinant of training outcomes. The refined model clearly indicates that a variety of other student input variables, such as reading level, academic motivation, educational level, and educational preparation are all associated with sizable path coefficients, indicating that they too have a significant impact on assessed quality of student performance. This is not an especially surprising finding since a wealth of literature exists indicating that motivation to perform and prior educational achievements are often critical determinants of training performance. Moreover, the magnitude of the coefficients associated with academic motivation, educational level, and educational preparation seem to indicate that in constructing a manpower allocation system of maximum effectiveness, these indices of student quality should be taken into account. Further, it appears that there might be substantial value in considering some index of maturity, such as age, given the sizable path coefficient produced by this variable. Although an attempt was made to examine interest, the available measures of this variable made it impossible to effectively assess the impact of interest on the assessed quality of student performance. Thus, this issue must remain open until more effective and appropriate interest measures become available.

In addition to recognizing that aptitude is only one of a number of variables that influence the quality of student performance, it must also be recognized that aptitude and its effects are in part imbedded in relationships with a number of other variables. Thus, when considering the potential impact of aptitude requirement adjustments, one must view these effects as being complex, multifaceted effects that are exerted through a variety of closely related variables.

One of the more interesting and significant findings generated by the model is the manner in which aptitude, or for that matter any student input variable, influences training outcomes. Aptitude and other student inputs have a strong direct impact on the assessed quality of student performance. However, the model indicates that student inputs have no direct effect on distal training outcomes such as academic attrition, nonacademic attrition, and retraining. Rather, student inputs affect the assessed quality of student performance, which in turn affects either academic counseling or nonacademic counseling. Retraining time, academic attrition, and nonacademic attrition represent potential negative outcomes of these counseling sessions.

This set of findings appears to conform to current operational procedures as they occur in the initial-skills training programs administered by ATC. For example, the fundamental importance of academic and nonacademic counseling in affecting distal training outcomes is an important finding which has a number of implications. First, it indicates that whether an individual is eliminated from training or retrained is ultimately in the hands of course instructors. Second, given the fundamental importance of instructors' counseling decisions in determining retraining and attrition, it appears that more attention should be given to this process in future research efforts, and that both academic and nonacademic counseling should be considered major training outcomes. Third, given the apparent importance of this process in mediating the relationship between performance and distal training outcomes, considerations underlying trainers' counseling decisions should receive attention not only in research efforts, but also with regard to policy formulation.

Two other points concerning the relationships observed among training outcome variables should be elaborated. First, although student inputs affect assessed quality of performance, which in turn is the fundamental determinant of counseling and attrition, the model indicates that a clear-cut distinction is made between purely academic performance problems and academic performance problems resulting from nonacademic causes such as a lack of motivation. Thus, a careful distinction should be made between academic and nonacademic outcomes despite their common cause. It should be noted that the present findings suggest that academic problems are far more common than nonacademic problems, and that academic counseling at times reveals nonacademic problems as indicated by the causal path from academic to nonacademic counseling.

The second point is that while SIA time represents a significant outcome variable, it is somewhat unique. SIA time was not found to be highly related to either student inputs or the assessed quality of student performance. Rather, SIA time was primarily driven by the difficulty of course subject matter and occupational difficulty. Thus, it appears that SIA time is truly employed as a remediation vehicle. However, the model also indicates that a repeated need for remediation may affect academic counseling and, in turn, academic attrition and retraining decisions. This suggests that though SIA is a somewhat unique variable, it is of some importance to conceptualization and prediction of training outcomes.

As was implied in the discussion of SIA time, the various course content variables also produced some interesting relationships. Broadly speaking, the refined model hypothesizes that training is driven by three primal variables: course subject-matter difficulty, occupational difficulty, and manpower requirements. That is, the model holds that courses are designed on the basis of the difficulty of the job, the difficulty of course training materials, and the number of students to be trained. This conceptualization of the training process fits quite well with the information obtained through the interviews, where it was noted that the job demands, yearly student flow, and training materials were the major factors considered in course design.

Of these three primal variables, only occupational difficulty was measured directly. Manpower requirements and subject-matter difficulty represent latent variables defined in terms of directly measured variables. Subject-matter difficulty was defined by the diversity of course material, the reading difficulty of training materials, expected attrition rates, and abstract knowledge requirements. Of these four variables, abstract knowledge requirements exhibited the largest loading for subject-matter difficulty, suggesting that abstract knowledge requirements are important for training design and training outcomes. Manpower requirements were defined by selective reenlistment bonus and yearly student flow. As expected, the path coefficients indicated that yearly student flow was the strongest index of manpower requirements.

Although it may be difficult to conceive of these three relatively straightforward variables driving course design, this hypothesis was strongly supported by the results obtained in the present effort. For instance, these three variables yielded Rs for the prediction of course length, day length, student-faculty ratio, instructor quality, instructor experience, instructional support, and feedback intensity in excess of .54 and averaging near .60. Thus, these three primal variables provide an excellent definition of lower-order course variables. Moreover, the nature of the paths between these primal variables and the lower-order course variables was readily interpretable, thus supporting the validity of this conceptualization.

Two latent variables were among the lower-order course variables held to be driven by the three primal variables. The first was instructional support, which was defined by a combination of the frequency of use of instructional aids and the number of hours of hands-on instruction. This variable reflects the frequency of use and the amount of course time devoted to job task simulations. The second latent variable, feedback intensity, was defined by the amount of feedback and practice given a student. The relation of practice to feedback intensity may, at first glance, appear ambiguous. However, the relation is based on the fact that feedback in basic resident technical training is required by unit of instruction. Thus, less time per unit equates to more rapid feedback.

Within the model, these seven course content variables were hypothesized to be capable of influencing assessed quality of performance and SIA time independently of the three primal course variables. With respect to the magnitude of these effects, course length, instructor quality, and feedback intensity had the greatest impact on both SIA time and the quality of student performance. This suggests that more rapid feedback, a better overall quality of instruction, and more instructional time enhance the quality of performance. On the other hand, the paths obtained for instructor experience, day length, student-faculty ratio, and instructional support

were relatively weak. This observation should not be taken as indicating that these latter variables are irrelevant to student performance. Rather, the results indicate that these variables have relatively less impact on training outcomes when the influence of the three primal course content variables is partialed out. This suggests that if any given course content variable is out of line with the program's status on course subject-matter difficulty, occupational difficulty, or manpower requirements, it might have a marked influence on the quality of student performance.

To this point, little attention has been given to the impact of the three primal course content variables on training outcomes. As the standardized path coefficients indicate, course subject-matter difficulty, occupational difficulty, and manpower requirements all have substantial effects on both assessed quality of student performance and SIA time. In fact, course subject-matter difficulty had the greatest effect on SIA time. It should also be pointed out that the primal course content variables generally had a greater impact on assessed quality of student performance than any other course content variable. Thus, it appears that the three primal course variables not only drive course design, but also constitute those course content variables most likely to influence student training performance.

One question that might arise at this point concerns the relative power of the course content and student input variables in determining assessed quality of performance. Overall, evaluation of the standardized path coefficients tends to indicate that the course content and student input variables make roughly comparable contributions to the prediction of assessed quality of student performance, with the student input variables showing a slight advantage. This is not an unusual finding, since previous research (Tyler, 1964) has indicated that what the individual brings to a course has a more important influence on educational outcomes than characteristics of the educational system. On the other hand, it should be recognized that course content variables did have a substantial impact on the assessed quality of performance. Taken as a whole, the foregoing considerations indicate that, although student inputs may be the most effective predictors of performance, both student inputs and course content variables should be considered in order to attain optimal performance prediction.

Before concluding this discussion, one additional set of comments seems in order. At first glance, the path coefficients obtained for many of the variables examined in the present investigation may seem low and might be viewed as indicating a lack of effective prediction. However, the size of the Rs generated by the model for each of the outcome variables was quite large, ranging from .50 for nonacademic attrition to .83 for academic attrition.

If one grants that the model provides a stable and accurate description of the training process, then the magnitude of the individual path coefficients can be viewed in a different light. Rather than diminishing the appropriateness of the model, they suggest that no single variable or limited set of variables is adequate for predicting training outcomes. This observation, in turn, confirms the initial premise of the current investigation that resident technical training is a highly complex process which can be adequately described only by considering a variety of student input, course content, and training outcome variables. Thus, the model developed in the present effort indicates that fully adequate predictions of training outcomes can be obtained only when training is conceived of as being a complex, multifaceted process involving a variety of student inputs and course content variables. Although this is not an especially unusual conclusion, it suggests that optimal description and prediction of the training process can never be attained without employing multivariate techniques capable of taking into account these complex interrelationships. Perhaps much of the value of the present effort lies in its recognition of this complexity, and its use of a heuristically appropriate modeling methodology to demonstrate the complexity of basic resident technical training.

Applications

The discussion has focused primarily on the empirical model of resident training developed in the present investigation, along with some of the conclusions that flow from the content of the model. However, since the model was developed for the purpose of making predictions concerning the impact of aptitude requirement adjustments on technical training outcomes, it is necessary to conclude the discussion by considering the potential applications of the model.

Given that the model provided both an accurate description of the initial-skills training process, as well as accurate predictions of training outcomes, a technical constraint that might limit application of the model must be examined. To employ the model on a routine basis for predicting training outcomes, it will be necessary to specify the status of the course on the various student input and course content variables. As a result, routine application of the model in the prediction of training outcomes requires that measures of student input and course content variables are readily available. Anticipation of this constraint resulted in the use of measures of student input and course content variables that are easily obtained from sources such as the PACE data file and standard training documents such as the POI, training plan, and other course materials. The only exception is the ratings of course abstract knowledge requirements made by the ARRO staff. However, given the simplicity of the measurement procedure for this variable, there would be little difficulty in using it to make similar ratings when the need arises.

The foregoing discussion addressed the major technical issues associated with application of the model. Therefore, it would now seem appropriate to turn to some of the specific applications of the model. Assuming the availability of requisite information describing student input and course content variables, the model could be used in a straightforward fashion to predict the effects of aptitude requirement adjustments on technical training outcomes. For a specified course, the average aptitude of individuals assigned to the associated job specialty on the basis of a given aptitude requirement minimum would be obtained, along with average values for other student inputs and values which describe the course's status on course content variables. These values would then be converted to standard scores and used with a series of mathematical equations to predict average values on the training outcome variables. These equations would produce predictions of training outcomes in standard score form. To facilitate interpretation, it would be desirable to convert the standard score predictions back to raw-score form. The whole student input model could be manipulated by adjusting the means of certain student inputs to obtain training outcomes at desired levels.

In addition to the applications of estimating student inputs required for entry into a training program, the model has a number of other uses. For instance, if a simulated change in aptitude minimums results in a predicted decrease in the assessed quality of student performance, either the primal course content variables or the lower-order course variables might be manipulated to compensate for the predicted decrease in performance. Hence, the model may be used not only to predict the effect that changing student inputs has on training outcomes, but also to suggest specific training strategies for compensating for negative effects of these changes.

In addition to compensating for changes in student inputs, the model can provide a framework for course design by evaluating changes in course subject-matter difficulty, occupational difficulty, or manpower requirements. Values for these primal course variables might then be used to predict expected values for lower-order course variables, such as course length or student-faculty ratio. Predicted values for these latter course variables as they follow from changes in job difficulty, course subject-matter difficulty, or manpower requirements might provide a basis for decisions concerning course design. Moreover, because the model specifies the relationships of the primal course content variables and the lower-order course variables

with the various training outome variables, the potential impact of proposed changes in course content on training performance can be predicted. If changes in course content result in predictions of decreased training performance, an attempt might be made to manipulate other course content or student input variables so as to avoid such a decrease.

Obviously, the model has many potential applications, including prediction of the effects of changes in aptitude requirement minimums and modifications in course design on training outcomes. However, an issue that is likely to arise in such applications is related to the multivariate nature of training outcomes. In the refined model, there are five training outcomes, specified as academic attrition, nonacademic attrition, retraining time, academic counseling, and nonacademic counseling, all flowing from the assessed quality of student performance and SIA time. Thus, in evaluating the effects of any simulated change in student input or course content variables, a variety of potential outcomes must be considered. Because multiple outcomes must be considered, it would be desirable to have some means of combining these outcomes into a single decision-making index. One way of accomplishing this is to estimate the costs associated with training outcomes. The resulting cost estimates would then provide a common framework for evaluating changes in student input or course content. Because the ATC Comptroller maintains training cost data for each course, it may be possible to employ these training cost data in the implementation of the model. Therefore, changes in training outcomes could be linked to training costs, and thereby serve as a basis of evaluating the overall cost impact of student input or course content adjustments.

This has been a fairly general discussion of potential applications of the model formulated in the present effort. This discussion has underscored the point that the model will not only serve the intended purpose of predicting the effect of aptitude requirement adjustments on technical training outcomes, but can also serve a variety of other purposes as well. Perhaps more important than these relatively pragmatic applications, the study may have made one other major contribution. By defining the variables relevant to technical training outcomes and establishing their interrelationships, the model provides a basis for facilitating understanding of the initial-skills training process as a whole.

V. CONCLUSIONS

The present effort was undertaken as part of a larger Air Force effort concerned with the enhancement of manpower allocation. More specifically, it was concerned with finding some technique for assessing the impact of changes in aptitude requirement minimums on technical training outcomes. To accomplish this, it was decided that an empirical model should be developed by which student input and course content variables could be related to training outcomes.

A series of interviews were conducted with technical training instructors and administrators to identify the student input and course content variables most likely to influence performance in basic resident technical training. Readily available measures of these variables were then specified. Subsequently, data describing the status of some 5,000 trainees in 39 courses were obtained, along with data for some 1,000 additional trainees in nine different courses. Path modeling procedures were used to develop an empirical model of the technical training process.

The resulting model provided an effective description of the relationships among student input, course content, and training outcome variables. The observed residual (variance unaccounted for) was only .19, and the model yielded an R of .75 against the assessed quality of student performance.

A number of interesting facets of the technical training process were identified during model development. For instance, although aptitude was one of the best predictors of the quality of student performance, it interacted with a variety of other student input and course content variables in determining training outcomes. Further, it appeared that course content variables tended to be defined by course subject-matter difficulty, occupational difficulty, and manpower requirements. Another important finding was that finally, the model indicated that counseling mediated the relationship between training performance and distal training outcomes such as retraining time and student elimination.

Results of the analyses indicated that the model could be used both to predict the effects of aptitude requirement adjustments and to enhance training course design. Moreover, it appeared that only a multivariate modeling approach, such as that employed in the present investigation, would allow effective predictions of Air Force initial-skills training outcomes.

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APPENDIX A: INTERVIEW PROTOCOL

Sample of Questions Asked Technical Training
Center Staff Members

Course Content

What determines course content?

How is the length of a course determined?

How much Instructional System Development (ISD) effort is done?

In the past couple of years, have there been any changes in the courses you are connected with (e.g., changes in content of courses; number of class hours per day; length of course; entry aptitude requirements)?

How are these changes accomplished?

What has been the effect of these changes on student performance, amount of recycling, attrition, quality of output, etc.?

If you encountered changes in the general aptitude level of your students, what would you do to preserve the quality of your product?

What changes would you like to see made in your courses and why do you think these changes would be beneficial?

How do student aptitudes affect performance in your courses? Is it very noticeable?

What changes were made in other aspects of the course to compensate for the changes in aptitude?

Have there been any changes in aptitude requirements to your courses? Where is a record of these changes maintained?

What differences have you noticed between non-prior-service students and those who are being retrained?

If no changes in aptitude requirements have been made, do you feel that changes in aptitude requirements should be made? Why?

Besides aptitude, what personal characteristics of students are most influential on their performance in training?

How do students' educational experiences affect their performance (e.g., the kind of courses taken)?

Which do you prefer: group lock-step or group-paced courses? Why?

How should the difficulty of a course be measured?

Can the difficulty of a block of instruction be estimated from Occupational Survey Report (OSR) task difficulty ratings?

What aspects of a course have the most effect on its difficulty?

How do you get feedback about your courses?

How is this information used?

Is it possible to use Career Development Course (CDC) completion as a measure of graduates' quality?

Student Assessment

How is student performance measured?

What are the differences between progress checks, performance tests, sampling written tests, and comprehensive written tests?

How are progress checks and performance tests conducted?

What determines which kind of measurement is to be used?

How and when are these measurements made?

What records are required to be kept on student performance?

Are there any important aspects of student performance that are not kept on the ATC Form 156?

How useful is the ATC Form 667 in recording progress checks?

How much consistency is there across instructors in grading progress checks or performance tests?

Have you ever retested students on block tests to measure reliability of tests?

What factors influence the grading of progress checks or performance tests?

How are these assessments combined into an overall assessment of student performance?

How is a student's final school grade (FSG) computed?

What is the usual distribution of FSGs?

Are any analyses made of FSG distributions?

What feedback is provided as a result of these analyses?

How are distinguished or honor graduates chosen?

What is the difference between the top students and the poorest students?

Where and how do these differences show up?

What are the main causes of poor student performance?

How well informed are students about the nature of the work they will be doing in the job specialty for which they are training? Does this affect their school performance?

Are those in the Guaranteed Training Enlistment Program (GTEP) better informed or motivated?

Do you have any courses where the nature of conditions of work tends to create stress among the students?

What inducements can lead to better student performance?

How do you determine when a student needs Special Individual Assistance (SIA)?

What determines how much SIA is given?

Should SIA be considered as additional training time or is it a different type of training?

Where is the information concerning SIA recorded and how accurate is it?

Who uses the SIA information and how is it used?

What determines when a student is recycled or washed back?

Where is information concerning trainee wash-back recorded and how is it used?

What determines when a student should be failed?

Does the policy toward attrition vary over the months or years?

What are the reasons for attrition and how do you determine which reasons to assign to a particular case?

What factors have the most effect on the various categories of attrition?

Course Quality

How is the quality of a course measured?

Where may information concerning course quality be obtained?

What regulations or directives govern the compiling and maintenance of course quality records?

Which are better indicators of course quality?

How and by whom is information concerning course quality used?

How far back do records concerning course quality go?

How are student attrition figures computed?

What kind of feedback concerning course quality do you get from the field?

How useful are student critique forms?

Instructor

What effect does an instructor have on how much a student learns?

In what ways do instructors influence student performance?

On the average, how many instructors teach in a single course?

How is the required number of instructors determined?

Are there times when there aren't as many instructors available as are required?

ATC Form 281 is used to evaluate instructors. Of the aspects measured by that form, which are the most important? Which the least important?

How should we measure instructor quality?

How does an instructor's field experience or lack thereof affect his/her performance?

What are the characteristics of good and poor instructors?

APPENDIX B: STUDENT MEASUREMENT GUIDELINES (ATCR 52-3)

DEPARTMENT OF THE AIR FORCE
Headquarters Air Training Command
Randolph Air Force Base, Texas 78150

ATCR 52-3

25 July 1982

Technical Training

STUDENT MEASUREMENT

This regulation establishes policy, assigns responsibilities, prescribes procedures, and provides guidance for student measurement in technical and military training programs consistent with AFM 50-2. It applies to all technical training wings, 3785FLDTG, School of Health Care Sciences, 3480TCHTG, and the Basic Military Training School.

1. Terms Explained:

a. **Appraisals.** A group of questions and (or) projects used to check the day-to-day learning process. Appraisals are an informal, optional measurement and are not a part of the recorded measurement program.

b. **Comprehensive Written Test.** Written test items used to fully measure student achievement of a knowledge oriented objective(s) not included on progress checks.

c. **Compromise of Test Materials.** Any act or occurrence whereby students gain unauthorized knowledge of contents of test materials.

d. **Criterion Checklist.** A reference or listing on ATC Forms 667 or 667A, Criterion Checklist, of course objectives that are designed to be assessed by progress checks. In courses without a POI, objectives are extracted from lesson plans and listed on the criterion checklist.

e. **Criterion Referenced Testing (CRT).** Test to determine if the behavior specified in the objective has been acquired. May involve multiple-choice, completion, true or false, matching, essay items, short answer or actual performance of a task.

f. **End-of-Course Test.** Written test items administered near the end of a course to check the retention of the knowledge component of selected objectives an optional quality control check.

g. **Master Copy of Written Test.** A copy of each written test annotated to (1) identify the correct answers, (2) show POI objective reference which each item supports, and (3) list the approved corrections and changes made in the test. It must also contain a statement showing approval for continued use when the test date is earlier than the POI date, or the course chart date for courses that have no POI.

h. **Measurement Plan.** A plan designating the method used to measure student achievement of the course objectives and indicating the correlation between test items, and POI objectives and the correlation between PO objectives and training standard items.

i. **Objective.** A precise statement of the student' behavior to be exhibited, the minimum standard o performance or proficiency expected and the condition under which the behavior is to be exhibited (AFM 50-2 attachment 1).

(1) Knowledge Oriented Objective. An objectiv originating on the basis of a training standard element(s requiring task or subject knowledge. Conditions an standards may be implied if they are clearly obvious.

(2) Performance Oriented Objective. An objectiv originated on the basis of a training standard element(s task performance. Standards may be implied if clearl obvious.

j. **Performance Exercise.** The means of providing th students practice sessions throughout the learning period

k. **Performance Test.** An instrument administered in test mode and environment after the teaching-learnin activity to verify student attainment of performanc oriented objectives.

l. **Performance Recheck.** A recheck of studen performance on a specific objective, normally administere near the end of the course. It is mandatory when a specia requirement has been identified in the training standard o where a separate agency certification is required. It i optional when objectives require added quality control.

m. **Progress Check.** The assessment of student ac complishment of knowledge or performance objective during the teaching-learning activity. Results ar documented on ATC Form 667 or 667A.

n. **Progress Checklist.** (ATC Form 98 or locall approved checklist) The breakdown of an objective int elements or steps necessary to determine whether eac student satisfactorily accomplishes an objective during progress check or performance test.

o. **Sampling Written Test.** Instrument used to sampl the knowledge components of each course objectiv assessed during a progress check.

p. **Test Item Pool.** A file of written test items which ca be used to construct or revise a test. Items may b handwritten, be a copy of a test replaced by a newe revision, or a copy of a test containing annotated propose changes (working copy). Maintenance of a test item pool i optional.

q. **Test Materials.** Tests or pages from a test, te booklets, scoring keys, test items in pools, complete

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AUL LSE - 1

answer sheets, test data forms, automatic data processing cards as well as calculations, diagrams, formulas, etc., used by a student while being tested.

r. **Training Deficiency.** A condition that prevents accomplishment of training requirement(s) and which cannot be corrected before the affected students graduate.

2. Student Measurement Concept. The ATC technical training student measurement program is predicated on valid, job relevant, and properly constructed objectives. Since the objectives specify precisely what behavior is to be exhibited, the condition under which the behavior will be accomplished, and state or imply the minimum standard of acceptable behavior, they are the basis for measurement of student achievement. Each criterion test item is based solely on the requirements specified in the objective which it is to measure. This program normally includes instructor assessment of each student's accomplishment of each objective during the teaching-learning environment through the use of progress checks. Progress checks are the most practical means of verifying accomplishment of each course objective. However, when it is more appropriate to delay the measurement of certain objectives and satisfy them through the use of comprehensive written and (or) performance tests, structure the measurement device in a manner which determines students' achievement of each objective tested. The objectives assessed by a progress check during the teaching-learning activity are sampled on unit, block, and (or) end-of-course written tests to aid in retention and act as quality control devices. Additionally, it is often appropriate to recheck certain performance oriented objectives with performance rechecks. Normative grading systems (grading on a curve) are not used.

3. Objectives of Student Measurement:

a. Ensure each student achieves every course objective before graduation.

b. Permit early identification of students who fail to attain objectives and need special individual assistance or additional training.

c. Inform students whether or not they are attaining the objectives, stimulate effective learning, and reinforce knowledges and skills.

d. Ensure students meet the performance recheck requirements, such as typing or code speed specified by using activities, or where a separate agency certification is required.

e. Provide data for use in:

(1) Determining teaching and learning effectiveness and improvement of the instructional system.

(2) Maintaining quality control.

(3) Establishing a permanent record of each student's achievement in the course.

(4) Selecting students for special recognition.

(5) Validating aptitude test batteries.

4. Policies:

a. Before graduation, each student achieves all course objectives as demonstrated by a progress check, comprehensive written test, or performance test and pass all sampling written unit, block, and (or) end-of-course tests. Students may graduate if failure to accomplish objectives is due to the existence of a training deficiency. Document training deficiencies as required in AFR 8-13 ATC Sup 1.

b. Student measurement is not required in orientation, symposium, and familiarization type courses. Award final course grade of satisfactory (S).

c. Use student measurement in all type 2, 3, and 4 courses (AFM 50-5) and military training courses except those in b, above.

d. Measurement of students attending type 1 and 5 courses follows the procedures specified in the contract and appropriate course documention or as specified by the agency responsible for establishing the curriculum for training. Where possible, measurement follows the intent of this regulation.

e. The procedures for airman basic military training courses:

(1) Record written test and performance test grades on locally designed form.

(2) Record performance test grades as satisfactory (S) or unsatisfactory (U).

(3) Use adjectival grades of outstanding (O), satisfactory (S), or unsatisfactory (U) for written tests.

(4) Record overall grades as outstanding (O), satisfactory (S), or unsatisfactory (U).

f. Time allotted for administration of written tests, test critiques, and performance tests is shown in the course chart and POI. The time allotted must allow the measurement of each student on each objective. Establish special policies and procedures consonant with AFM 50-29, as appropriate, for testing Security Assistance Training Program trainees. Frequent measurement is encouraged to minimize washback time and to provide early identification of students in need of special individual assistance.

g. Develop sampling written unit, block, and (or) end-of-course tests to sample the knowledge components of each objective assessed during a progress check. The primary purposes of these tests are to aid in retention, act as a quality control device, and assign grades. Establish a pass or fail point no lower than 60 percent.

h. When progress checks are not used to assess student accomplishment of knowledge oriented objectives, develop comprehensive written tests to determine student achievement. The pass or fail point is established by the standard stated in each objective.

i. Grades are assigned for both written and performance tests. Grade written tests using percentage scores. Performance tests may be graded using either the satisfactory(S) or unsatisfactory(U) method, or percentage scores. When the S-U method is used on performance tests, the final course grade is the average of percentage scores attained on written tests. When a percentage score is used on

performance tests, the final course grade is the average of the scores obtained on the performance and written tests.

j. Establish and maintain a documented course measurement plan indicating the measurement device used to satisfy each objective.

5. Responsibilities:

a. ATC TTSA establishes basic policy, provides guidance, and maintains surveillance over the student measurement program.

b. Training wings schools 3785FLDTG provide staff supervision and measurement expertise to ensure that student measurement as prescribed herein is implemented and remains consonant with the intent of this regulation.

c. Groups and departments implement and supervise the student measurement program according to this regulation by:

(1) Establishing the passing standard for each sampling written test. Do not set the minimum grade below the equivalent of 60 percent.

(2) Approving progress checks, written and performance tests, and related materials and instructions including revisions.

(3) Authorizing establishment and retention of test item pools.

(4) Ensuring that instructors and instructor supervisors are knowledgeable of the procedures for conducting the measurement program for their respective courses.

(5) Providing guidance and measurement expertise to individuals involved in preparing draft tests and test materials, administering and critiquing progress checks and tests, and documenting measurement results.

(6) Conducting test analysis and revising the measurement program as required.

6. General Procedures:

a. **Measurement Plan:**

(1) For each course objective, document the type of measurement device (performance test, progress check, or comprehensive written test) used to satisfy each objective, the test number, the specific measurement item(s) covering each objective, and the training standard item supported by each objective.

(2) The measurement plan may be documented on the POI, part I of the lesson plan, or on a separate document.

b. **Progress Checks:**

(1) List or reference the objectives on ATC Form 667 or 667A that are to be assessed through the use of a progress check.

(2) Each student's performance is evaluated by the instructor on each objective that is to be satisfied by a progress check while the student is in the teaching-learning environment. The instructor determines if the student successfully accomplished the objective based on the behavioral outcome stated in the objective applicable checklist (ATC Form 98 or locally produced checklist), and his or her judgment of the student's performance. For objectives that require group activity, the instructor rates each member according to the individual's performance and participation in the group.

(3) When a progress check cannot be conducted during the block because of equipment malfunction, nonavailability, etc, the student may continue in training provided the progress check or a performance test on the same objective is completed before graduation. When the equipment malfunction, nonavailability, etc., cannot be corrected before graduation, document this as a training deficiency. See AFR 8-13 ATC Sup 1.

(4) After the instructor determines that the student has satisfactorily attained an objective identified on the criterion checklist, an "S" or percentage score is entered on ATC Form 667 or 667A. Enter "U" for unsatisfactory.

(5) If, after special individual assistance or practice, a student cannot attain a satisfactory rating on a progress check, then consider washback or removal from training action.

(6) Retain completed ATC Form 667 or 667A until the results are recorded on ATC Form 156, Student Record of Training. Retain the ATC Form 667 or 667A completed during validation until the next course revision. Destroy it according to AFM 12-50, table 50-1, rule 12.

(7) Record the overall rating for the block as an "S," "U," or percentage score of the ATC Form 156 or 379, Attendance and Rating Record. If a student is removed from training, annotate the ATC Form 156 or 379 as prescribed in ATCR 52-11.

c. **Performance Tests:**

(1) Test each student on every objective that is designated for a performance test. When the objective calls for group performance, the instructor rates each member according to the individual's performance and participation in the group.

(2) Develop a checklist for each objective measured by a performance test using ATC Form 98 or locally approved checklist. The checklist should include specified standards relative to instructor assistance and safety, a breakdown of technical data, an explanation of its use, or any other information necessary to ensure a high degree of objectivity in determining satisfactory performance.

(3) Develop standardized instructions to the examiner for administering and critiquing the performance test. See attachment 3.

(4) When practical, an instructor other than the individual who taught the class should administer the test.

(5) Inform the students of their grades and critique their performance as soon as practical after administration.

(6) Record performance test grades for each objective (performance test item) as "S," "U," or percentage score on ATC Form 98 or locally developed checklist.

(7) Record the overall rating for the performance test as "S," "U," or percentage score on the ATC Form 156 or 379. A satisfactory performance test rating requires successful accomplishment of each objective measured at this test point in the course.

(8) Retain the completed ATC Form 98 or locally approved form until results are entered on ATC Form 156 or 379. Retain the ATC Form 98 accomplished during validation until the next course revision.

(9) Students who fail performance tests are considered for special individual assistance, washback, or removal from training. If a student is removed from training, annotate the ATC Form 156 or 379 as prescribed in ATCR 52-11.

d. **Written Tests:**

(1) Develop a sampling written test for those objectives assessed by progress checks. The sampling should include every objective when all test versions are combined. No single test version must include every objective. Proper rotation of test versions includes all objectives over a period of time and permits validation of each test item. The difficulty, complexity, criticality, and scope of behavior specified by the objective is used in determining the number of test questions required for each objective.

(2) If the knowledge objectives have not been satisfied through the use of progress checks, construct a comprehensive written test so as to provide for documentation of the attainment of the objectives tested. The number of questions relating to a particular objective is determined by the objective itself. For example, if an objective includes a standard of "4 out of 5," the test must have five questions on that objective and the student must get at least four of these questions correct to demonstrate satisfactory achievement of the objective.

(3) Develop enough test versions (minimum of two) for each measurement point in a course to provide alternate tests in the event of a test compromise. The selection of questions should not exceed 25 percent of the questions in any other test version. Do not count scrambled or resequenced items as test version.

(4) Develop standardized instructions to the examiner for administering and critiquing the written test. See attachment 4.

(5) Unsupervised breaks are not taken during the administration of written tests. Students may leave the room only when they have completed their test and on submission of their testing materials to the examiner.

(6) Use technical data whenever it contributes to on-the-job realism.

(7) Tests are critiqued and students informed of their grade as soon as practical after administration. Scored answer sheets and copies of the test are returned temporarily to all students for their review during the critique (except BMT). Take care to reduce the possibility of test compromise.

(8) Record written test results on ATC Form 156 or 379 as a percentage score. Circle failing scores.

(9) When a student receives a failing grade, follow the procedures in ATCR 52-26, paragraph 1k. When a student passes the retest, record the minimum passing score allowed by the test as that student's grade and indicate in the remarks section of the ATC Form 156 the student's actual score. Remove a student from training when it becomes apparent the student cannot complete the course.

(10) Conduct an analysis of test items as soon as possible after each test for the first three classes, 200 cases, or 1 year, whichever is sooner. After initial validation, conduct further test analysis on a random basis. The intent of test item analysis is to ensure quality control and determine the effectiveness of instruction, course materials, and test items. Place emphasis on "high" and "low" ("high" miss -50 percent or more of students miss a question and "low" miss - less than 5 percent of students miss a question) miss rates to determine what corrective action, if any, is required. Look for trends of "high" and "low" miss items over an extended period of time. Document test item analysis on ATC Form 668, Test Data, (see attachment 1), a locally produced form, or a computer product. Maintain test analysis until a test is revised, deleted, or would serve no further purpose.

e. **End-of-Course Written Test/Performance Recheck:**

(1) Construct end-of-course tests to check selected knowledge oriented objectives for courses where such a test is necessary or desirable. Performance rechecks are administered where a special requirement such as a typing or code speed is included in the course, where separate agency certification is required, or when objectives require added quality control. Other objectives may be checked on a sampling basis as deemed appropriate. The amount of time devoted for end-of-course testing and performance rechecks should be consistent with the need for such testing and be cost effective.

(2) Each student is administered a performance recheck on each objective developed for special requirements and certification.

(3) Concrete terms (such as words per minute, etc.) used for test grades are recorded in ATC Form 156, item 3, part V.

(4) When end-of-course tests are used, each student must obtain a passing score on the written test to be graduated. Test grades are recorded on ATC Form 156 or 379.

(5) Students who fail to satisfactorily complete performance rechecks or do not meet certification or special requirements will not be graduated.

f. **Appraisals:**

(1) Use appraisals as an interim check for retention and early identification of students who need special individual assistance.

(2) Recording or maintaining grades and control is not required.

(3) Appraisals may be administered without documentation in the POI.

7. Control of Testing Materials:

a. Store test materials in a storage cabinet secured with a combination lock, in a safe, or other comparable secure area. Test materials maintained in word processing centers

on tapes or floppy discs, and those in draft stages will be secured in the same manner as a finalized test; however, the provisions of paragraphs 7c and d below do not apply. Control performance tests and materials only when they contain information that could cause a compromise of the test.

b. Restrict access to materials in locked storage to the minimum number of authorizd personnel necessary.

c. Maintain ATC Form 1005, Test Control, when a test is removed from a locked storage area for any purpose, and ensure pertinent details are entered in the "issued to" columns. The ATC Form 1005 is not a controlled form and need not be stored in a secured area.

d. After a test is administered, the test administrator examines the test booklets for missing pages, removes pencil marks, and returns booklets to test custodian. The test administrator certifies to the reusability of the tests by signing the test control form. Custodian's signature indicates all issued tests have been returned and the current inventory count as shown on ATC Form 1004, Test Inventory, is accurate. After the last entry, destroy ATC Forms 1005 immediately according to AFM 12-50, table 11-1, rule 4.

e. Use a separate ATC Form 1004 to maintain a running inventory of each different controlled test and its related test materials. Keep reserve stocks of controlled tests to a minimum. Except for course validation file copy, destroy outdated controlled tests and related test materials within 10 duty days after implementation date of the replacement test. Immediately destroy loose pages left over after controlled tests are assembled or maintain inventory of loose pages on ATC Form 1004. Immediately destroy closed out ATC Forms 1004 according to AFM 12-50, table 11-1, rule 4.

f. Suspend use of a compromised test or one suspected of being compromised for a period determined by training development sections or measurement sections.

g. Complete ATC Form 1004 as follows:

(1) Type or make all entries in ink.

(2) The master copy of the written test is not included in the balance on hand column. The master copy is identified by writing across the top center of the first page "Master Copy" with no numerical or alpha identifier.

(3) Make a separate and complete entry for each type of material used. Where necessary, use more than one line in the identification of material and action taken column.

(4) Custodians Block. Enter statement, "Posted on storage cabinet."

(5) Identification of Test Materials. Use the following code to identify miscellaneous test materials:

(a) K - test key(s).

(b) D - test data form(s).

(c) Additional coding at user discretion.

(6) Transaction Number. Each individual transaction is numbered in sequence.

(7) Balance on Hand. After each transaction is completed, enter the new balance in the column provided. If one series of tests is destroyed and the same ATC Form 1004 is used for the subsequent series of tests, start the transaction number over at 1.

h. Destroy completed answer sheets for written test immediately after results have been recorded and test item analysis is completed, unless required for specific projects; in this case maintain an inventory on a general purpose form.

i. Control classified tests under the above provisions in addition to those safeguards outlined in AFR 205-1 or other applicable security directives.

8. References:

a. AFR 8-13/ATC Sup 1, Air Force Specialty Training Standards.

b. AFM 12-50, Disposition of Air Force Documentation.

c. AFM 50-2, Instructional System Development.

d. AFM 50-5, USAF Formal Schools Catalog.

e. AFM 50-62, Principles and Techniques of Instruction.

f. AFP 50-58, Handbook for Designers of Instructional Systems, volume III.

g. ATCR 50-21, Field Training Detachment (FTD) Program.

h. ATCR 52-6, Curricula Documentation.

i. ATCR 52-11, Student Record of Training.

j. ATCR 52-26, Student Scheduling and Administration.

k. ATCR 53-1, Faculty Boards.

l. ATCM 52-9, Guide for Special Training.

m. AFR 205-1, Information Security Program.

9. Supplements. Each center and school OPR coordinates supplements to this regulation with HQ ATC TTSA for approval before publication.

10. Implementation. Revise each course to comply with the provisions of this regulation during the next course revision or within 1 year of the date of this publication, whichever is sooner.

11. Forms:

a. **Prescribed.** ATC 98, 667, 667A, 668, 1005, and 1004.

b. **Adopted.** ATC 156 and 379.

THOMAS M. RYAN, JR., General, USAF
Commander

PHILIP T. ROBERTS, Colonel, USAF
Director of Administration

4 Attachments
1. Completion Instructions for ATC Form 668, Test Data
2. Completion Instructions for ATC forms 667 and 667A
3. Instructions to the Examiner—Performance Test
4. Instructions to the Examiner—Written Test

SUMMARY OF CHANGES

This regulation clarifies guidance concerning written and performance tests; differentiates between knowledge and performance objectives; authorizes the use of progress checks to satisfy objectives; establishes the use of the ATC Form 668 as optional for test analysis; authorizes the use of a sampling written block tests and end-of-course tests as retention devices; adds the requirement to list all objectives assessed by progress checks on the ATC Form 667 or 667A; authorizes the conversion of performance test results to a percentage score and count as part of the overall course grade; adds the requirement to have a documented measurement plan; clarifies the test control procedures for tests stored in word processing centers on tapes or floppy discs; establishes the requirement to have supplements to this regulation approved by this headquarters before publication; and establishes implementation procedures for complying with the provisions of this regulation.

COMPLETION INSTRUCTIONS FOR ATC FORM 668, TEST DATA

The numbers below refer to corresponding circled numbers in specific locations on ATC Form 668 shown in figure A1-1.

1. Enter class number and section or shift of the group tested. *Example:* 681211A. For self-paced courses, enter date test data was computed.

2. Enter the number of students in the group tested. Do not count or use any answer sheets of retests or foreign students. *Example:* 8.

3. Enter the last name of instructor that taught the group. *Example:* Brown. In self-paced or multigroup entry courses leave blank.

4. Enter the course number. *Example:* 3ABRXXXX.

5. Enter number of this specific test. *Example:* W312-1.

6. When the form has the required number of groups recorded in sections 1 through 5, enter the total number of students recorded in sections 1 through 5 in this space. *Example:* 42.

7. Draw a heavy line through or block out the correct answer for each question on the test.

8. Using the answer sheets (ATC Form 26 or 26a) record the total answers selected in error in the appropriate A, B, C, D, or E column for each question. Tally may be accomplished on a separate sheet. Destroy tally sheets immediately after posting totals on ATC Form 668.

9. In the appropriate "Number Wrong Items" column enter the total missed by the entire group for each question.

10. When the form has the required number of groups recorded in the "Number Wrong Items" columns, enter the total of the misses for each question in the "Total Wrong" column.

11. Enter the difference between the "Number of Cases" (6) and the "Total Wrong" (10) column in the "Total Right" column.

12. Enter all the obtainable percentage grades from 100 down to below the passing point.

13. Indicate in the proper columns (1 through 5) the number of students in each class attaining each grade. For self-paced and multigroup entry courses record the accumulated number of cases attaining each grade.

14. When the form has the required number of groups recorded, enter the total number of students attaining each recorded grade.

15. A heavy line is drawn through this section just under the minimum passing grade to make the grade distribution more meaningful.

16, 17, and 18. Obtain the class average for each group. If in group 1, eight students took the 40 questions test there is a total of 320 answers. By adding the numbers missed in column 1 under the "Number Wrong Items" section a total of 73 misses is counted, (16). By subtracting the number of questions missed (73) from the total possible answers (320) the result is the total number of correct answers (247) which when divided by the total possible (320) gives the class average—77.2, (17). Use the same method to obtain the average difficulty of the completed ATC Form 668 (18).

19. Enter the test item number. When a test consists of more than 50 questions, simply continue the count on another ATC Form 668.

NOTE: See sample completed ATC Form 668 in figure A1-2.

	1	2	3	4	5		
CLASS NUMBER	1					COURSE NUMBER 4	TEST AVERAGE 18
NUMBER OF STUDENTS	2					TEST NUMBER 5	NUMBER OF CASES 6
NO OF INSTRUCTORS	3						

EVALUATION OF SPECIFIC ITEMS OF TEST — EVALUATION OF ENTIRE TEST

ITEM NO	ANSWERS SELECTED IN ERROR A	B	C	D	E	Number Wrong Items 1	2	3	4	5	TOTAL Wrong	Right	Grade	Number Making Specified Grade 1	2	3	4	5	TOTAL
19	7	8				9					10	11	12	13					14
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
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24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
32																			
33																			
34																			
35																			
36																			
37																			
38																			
39																			
40																			
TOTAL						16													

CLASS AVERAGE	1 17	2	3	4	5

ATC FORM FEB 82 668 PREVIOUS EDITION MAY BE USED TEST DATA

Figure A1-1. Annotated ATC Form 668

	1	2	3	4	5	COURSE NUMBER	TEST AVERAGE
CLASS NUMBER	681211A	690102B	690115B	690129A	690129B	3ABR XXXX	68.8
NUMBER OF STUDENTS	8	10	7	9	8	TEST NUMBER	NUMBER OF CASES
NO OF INSTRUCTORS	Brown	Smith	Jones	White	Smith	W312-1	42

EVALUATION OF SPECIFIC ITEMS OF TEST

ITEM NO	ANSWERS SELECTED IN ERROR: A					B					C					D					E					Number Wrong Items					TOTAL	
																										1	2	3	4	5	Wrong	Right
1											1	4	2	5	4											1	4	2	5	4	16	26
2					1							1					1	1					1			0	2	2	0	1	5	37
3	1	2	1	1	2	1		1	2	2	2	5	1	3	2						2	2	1		1	6	9	3	7	7	32	10
4	1	1	1				1	1				1	2		1						1	1				2	4	4	0	1	11	31
5		1	1	1			1	1	1	2						1		1		1		1	1	1		1	3	4	3	3	14	28
6						1						1						1	1			1			1	1	2	1	1	1	6	36
7	2	1		1	1	1	2	2		1		1	1		1	1	1		2	1						4	5	3	3	4	19	23
8						1	2	3				3	1		1	1	2	1	4	3	1	2	2	3	1	3	9	7	7	5	31	11
9		1					1		1								1								1	0	3	0	1	1	5	37
10		2		1			1		2							2	1				1	1			2	3	5	0	3	2	13	29
11		1					1	1		1			2		1									1	2	0	2	3	1	4	10	32
12		1			1					1							1									0	2	0	0	2	4	38
13	2							1	2								1		1						2	2	1	1	3	2	9	33
14						2	1		1			1		1			1								1	2	3	0	2	1	8	34
15	1	1				1	1											2								2	2	2	0	0	6	36
16		1	1				3						1	2								1			1	0	5	2	2	1	10	32
17												1														0	1	0	0	0	1	41
18	1	2			1						1	1			1		1		1			1	2		1	2	6	2	1	3	14	28
19						1	4	1	1		1	2	1	3		1	1	1	2			2		1		3	9	3	7	1	23	19
20			1						1					1											1	0	0	1	2	1	4	38
21				1	3	1	2	2		1		1	2		1		1	2		1						1	4	6	1	6	18	24
22			2	2								1		1	1		1		2		1				1	1	2	2	5	2	12	30
23	1												1		1								1	2		1	0	2	2	1	6	36
24							1	2						2												0	1	2	2	0	5	37
25	2		1	1		1	1	1	1	2	3	1	1	1			3	1	4	1						6	5	4	7	3	25	17
26	1		1	3							2	1		1			1					1	2		2	3	3	3	4	2	15	27
27	3	1	1		2	1	2	2		1		1	1		1						1	3	1	1		5	7	4	2	4	22	20
28	1				3	1		1									1	1	1		1	1		3		3	2	2	4	3	14	28
29						1	2			2		3			1		1		1				3	2		1	6	3	3	3	16	26
30								1	4			1		1		1	2					4		1	3	1	7	1	6	3	18	24
31		5		1	4		3	1	1		2		1	1		1	1	3	1							3	9	5	4	4	25	17
32	2				1						1				1		1		4		1	2			1	4	3	0	4	3	14	28
33	1	3		3	2							2	1		1		1	1		1	4	1	1		2	5	7	3	3	6	24	18
34			3	1			1		1			1		2							2	2			2	2	4	3	4	2	15	27
35				1				3	1		1		4	1						2						1	0	7	3	2	13	29
36						1					1		3				1	1		1				4	1	2	1	4	4	2	13	29
37	1	2	1	1		1	3		1				1	1								1	1	1	2	2	6	3	4	2	17	25
38														2												0	0	0	2	0	2	40
39													1	1					1						3	0	0	1	2	3	6	36
40		1											1						1						1	0	1	1	1	1	4	38
TOTAL																										73	145	96	115	96		

EVALUATION OF ENTIRE TEST

Grade	Number Making Specified Grade: 1	2	3	4	5	TOTAL
100						
98						
95						
93						
90				1		1
88	1					1
85				2	1	3
83	1				2	3
80	2	2	2	1		7
78	2		1			3
75		1			1	2
73		1				1
70	1					1
68			1	1		2
65						
63	1				2	3
60		1	1	1		3
58				1	1	2
55		4	1			5
53						
50		1			1	2
48						
45				1		1
43				1		1
40						
38			1			1

CLASS AVERAGE	1	2	3	4	5
	77.2	63.8	65.7	68.1	70.0

ATC FORM FEB 82 668 PREVIOUS EDITION MAY BE USED UNTIL STOCK IS EXHAUSTED. TEST DATA

Figure A1-2. Sample Completed ATC Form 668

COMPLETION INSTRUCTIONS FOR ATC FORMS 667 AND 667A

1. Type or make all entries in ink.

2. Before students enter a block of instruction, or immediately thereafter, prepare a criterion checklist consisting of as many ATC Forms 667 or 667A as required.

3. Enter the POI paragraph reference or the objectives which is measured by progress checks on ATC Form 667 or 667A.

4. Use ATC Form 667A for FTD courses and courses without a POI to record objectives.

5. Before administering a progress check, tell the student what is expected and explain that the rating received depends on his or her performance.

6. Completion of blocks on ATC form 667.

a. Course number, block number, instructor's name, grade, and initials are self-explanatory.

b. Under student's name enter last name and initials of each student attending the block of instruction.

c. Opposite the POI paragraph reference on ATC Form 667, enter an "S" for satisfactory, a "U" for unsatisfactory, or percentage score.

INSTRUCTIONS TO THE EXAMINER—PERFORMANCE TEST

EXAMPLE

DEPARTMENT OF THE AIR FORCE

TEST II

USAF Technical Training School

MEASUREMENT

COURSE All courses

SUBJECT Instructions to the Examiner (Performance Test)

OBJECTIVE To provide standardized instruction for test administration and space to include a list of the tech dat that will be used

INSTRUCTIONS.

1 When a controlled performance test is administered or removed from the locked storage area for any purpose, ensu that the date, time, number sequence of tests issued, and the signature of the person to whom the test is issued are entered o the ATC Form 1005, Test Control.

2 Unsupervised breaks are not permitted during the performance test.

3 Keep the testing area free of distractions as much as possible during examination. Administer makeup test in a quie area or lab atmosphere free from all interferences or distractions.

4. Student notes and materials should be covered or kept in a folder during the examination period.

5 Use of tech data during test periods is permitted and encouraged when it contributes to on-the-job realism provided it use does not compromise the test.

6 Scratch paper should be furnished by the instructor if needed and collected with the answer sheets and examinations

7. Clearly indicate time available for taking examinations to the students and what is required for satisfacto accomplishment

8 Advise students if they are authorized to ask questions or receive instructor assists during the testing period.

9 If group testing is required, ensure each student understands their role(s) as a group participant.

10 Instruct students not to mark test booklets.

11 Tests are critiqued and each student informed of their score as soon as feasible after administration.

12. Copies of the test should be returned temporarily to the students for their review during the critique Take care to reduce the possibility of test compromise, therefore, during the critique period use two instructors if possible Students ar not permitted to use any written materials or recording equipment and are not permitted to leave the room.

13 Instructors check test booklets for markings before returning to the storage area

14 The person actually returning the examinations to the custodian certifies the examinations are clean, even though tha person may have obtained custody of the examinations through reissue

15 List technical data required during this test administration

INSTRUCTIONS TO THE EXAMINER—WRITTEN TEST

EXAMPLE

DEPARTMENT OF THE AIR FORCE

TEST ID

USAF Technical Training School

MEASUREMENT

COURSE All courses

SUBJECT Instructions to the Examiner (Written Test)

OBJECTIVE To provide standardized instruction for test administration and space to include a list of the tech data that will be used

INSTRUCTIONS:

1. When a test is administered or removed from the locked storage area for any purpose, ensure that the date, time, number sequence of tests issued, and the signature of the person to whom the test is issued are entered on the ATC Form 1005, Test Control.

2. Unsupervised breaks are not permitted during measurement test.

3. Keep the classroom free of distractions such as charts, diagrams, and cutaways during examination. Administer makeup test in a quiet classroom or lab atmosphere free from all interferences or distractions.

4. Student notes and materials should be covered or kept in a folder during the examination period.

5. Use of tech data during test periods is permitted and encouraged when it contributes to on-the-job realism provided its use does not compromise the test.

6. If possible, seat the students in alternate seats. In some classrooms it may be possible to move the chairs farther apart.

7. Scratch paper should be furnished by the instructor if needed and collected with the answer sheets and examinations.

8. Clearly indicate time available for taking examinations to the students and minimum passing grade.

9. On multiple choice type questions instruct the students to select the best choice of the answers listed.

10. Advise the students to answer the questions they are confident of first, saving the more difficult questions until last.

11. Instruct students to fill in all applicable headings on the answer sheet.

12. Instruct students not to mark test booklets.

13. Tests are critiqued and each student informed of their scores as soon as feasible after administration

14. Scored answer sheets and copies of the test should be returned temporarily to the students for their review during the critique. Take care to reduce the possibility of test compromise; therefore, during the critique period use two instructors if possible. Students are not permitted to use any written materials or recording equipment and are not permitted to leave the room

15. Review test analysis data

16. Instructors check test booklets for markings before returning to the storage area

17. The person actually returning the examinations to the custodian certifies the examinations are clean, even though that person may have obtained custody of the examinations through reissue

18. Annotate a copy of these instructions for each written test and issued with the test

19. List technical data required during this test administration

APPENDIX C: STUDENT RECORD OF TRAINING
(ATC FORM 156)

```
3ABR30434  000  830401  U  T     E3
                            SEX: M
                4
           CURR-GD:     32
INDCTR-GUARNTD-AFSC: YES
DOB: 640228        BTT-STU-TYPE: 1
STU-SOURCE: A      COMMAND/OGA: J1
TRAVEL STATUS: 4   SGN: 3413
DATE-ARR:          ENTRY: 830401

         APTITUDE-SCORES
GENERAL:      85  ADMINISTRATIVE: 75
MECHANICAL:   85  ELECTRONICS:    85
RADIO OPER:       AFQT:           88
EDP APT:          COMPREHEN:    12.5
VOCAB:      12.4  COMPOSITE:    12.4
EDUCATION:     D  ENDASC: KBOYFFJX
```

III. DISPOSITION

1. GRAD DATE: 4 OCT 1983

2. ELIM DATE:

3. REASON FOR ELIMINATION (Disenrollment)

ADMINISTRATIVE DISENROLLMENT

	ACAD DEFICIENCY		EXCESS ABS
	MED DISQUAL		RECALL PARENT ORGN
	SCTY ISSUES		ADMIN ACTION
	INIT INELIG		DIR OF HQ
	SEP SERVICE		DEATH
	LACK INSTR ADAPT		OTHER

FACULTY BOARD DISENROLLMENT

	ACAD DEFICIENCY		MIL TNG DEFICIENCY
	LACK INSTR ADAPT		SELF-INIT ELIM
	PREJUDICIAL CONDUCT		OTHER

4. TRANSFERRED TO

1962 CG(AFCC) Kadena ABS Ja
APO SF 96239 18CSG

IV. ACHIEVEMENT

1. CRS TITLE: Ground Radio Communications Specialist

2. CURR CL NR: 830401 T

3. TNG DEPT: 3410

4. TNG BR: TTKSG

5. CLASS CHANGES

CL NR	DATE ASGD	REASON
830401 T	27 JUN 83	Admin W/B

6. ABSENCE RECORD

DATE	BLK	HRS	DATE	BLK	HRS

	7. BLOCK TITLES	8. CC TNG HRS	9. STU TNG HRS	10. TEST GRADES		11. BLK GR
I	DC Circuits	45	45	100		100
II	AC Circuits	45	45	100		100
III	RCL Circuits	37.5	37.5	98		98
IV	Solid State Devices & Application	60	60	76		76
V	Wave Generation and Shaping	45	45	88		88
VI	Soldering and Electron Tube Principles	30	30	93		93
VII	Transmit/Receive Systems	37.5	37.5	93		93
VIII	Introduction to Computer Logic	75	75	96		96
IX	Computer Circuits	75	75	90		90
X	Introduction to Ground Radio	37.5	37.5	93		93
XI	Receiver Principles	60	60	80		80
XII	Transmitter Principles	75	75	80		80
XIII	VHF Transceiver	60	60	97		97
XIV	UHF Transceiver	75	75	90		90
XV	Control Tower Communications Sys	75	79.5	65		70
XVI	SSB Transceivers	105	105	88		88
XVII	HF Receivers	34.5	34.5	92		92

REPEAT - RETEST DATA

Blk	Score/Min-Passing
XV	98 / 70

DANIEL J. VERZWYVELT, GS-12
Acting Chief, Ground Radio Branch

12. TOT CC HRS: 972

13. TOT STU HRS: 976.5

14. FINAL CRS GR: 90

ATC FORM 156 JUL 71 PREVIOUS EDITIONS OBSOLETE

STUDENT RECORD OF TRAINING

V. INDIVIDUAL PROGRESS RECORD

1. REMEDIAL INSTRUCTION					2. COUNSELLING			
DATE	BLK NR	SUBJECT/OBJECTIVES	HRS	INSTR CERT	DATE	REASON A	REASON N	COUNSELLOR NAME/LVL SUPVN
9 Sept 83	XV	Console	1.5	[illegible]	5 Sept 83	✓		Hansen Inst
12 SEPT 83	XV	Console	1.5	[illegible]	7 SEPT 83	✓		Buchanan Instr.
13 SEP 83	XV	CONSOLE	1.5	LBS	7 SEPT 83	✓		Campbell Instr Supv.

Blk	Instructor	Blk	Instructor
I	A1C Reichert	X	M. Havard, GS-9
II	A1C Reichert	XI	Koch/ [illegible]
III	SSgt Hanson	XII	CARR GS-5
IV	SSgt Hanson	XIII	MAYES
V	A1C Gooch	XIV	Franks
VI	A1C GOOCH	XV	Buchanan
VII	SRA Gooch	XVI	Lipscomb
VIII	SSgt Hanbearson		
IX	SSgt Harberson		

3. REMARKS

MILITARY TRAINING 68 HRS

Course Chart date 17 Aug 81
Effective w/CL 830401

APPENDIX D: AVERAGE DIFFICULTY RATINGS BY HIGH SCHOOL COURSE

#	Title	Average Rating	#	Title	Average Rating
1	Speech	2.4	22	Hydrology	3.7
2	Algebra	4.1	23	Hygiene	1.5
3	Electronics	3.4	24	English	3.8
4	Biology	4.0	25	Industrial Arts	1.8
5	Accounting	3.0	26	Logarithms	4.0
6	Business Math	2.6	27	General Business	2.4
7	Chemistry	4.6	28	Business Administration	3.0
8	Commercial Art	2.1	29	Driver Training	1.5
9	Mechanical Drawing	2.4	30	Geography	3.1
10	General Science	3.0	31	Management	2.9
11	Geometry	4.2	32	Marketing	2.7
12	Journalism	3.4	33	Mechanical Theory	3.4
13	Zoology	3.8	34	Merchandising	2.2
14	Physics	4.9	35	Home Economics	1.7
15	Psychology	3.7	36	Business Machine Operator	1.5
16	Projection Equipment	1.6	37	Statistics	4.2
17	Radio Repair	2.5	38	General Math	2.6
18	Trigonometry	4.4	39	Shop Math	2.1
19	Use of Blueprints	2.8	40	Vocational Guidance	2.4
20	Anatomy	3.9	41	Music	2.2
21	Auto Repair	2.6	42	Agriculture	2.3

APPENDIX E: COURSE CONTENT VARIABLES BY COURSE

	Specialty Code	Sample [a]	Course Length (Hours)	Academic Day (Hours)	Student-Faculty Ratio	Instructor Quality	Instructor Experience	Use of Aids	Hands-On Instruction	Feedback	Practice	Reenlistment Bonus	Yearly Flow	Occupational Difficulty	Reading Difficulty	Diversity	Expected Attrition	Abstract Knowledge
Chanute Technical Training Center																		
Aircraft Environmental Systems Mech.	42331	M	508	6	4.3	2.4	33.7	.42	.57	.37	7.5	1	532	111	10.3	67	.10	3.4
Aircraft Fuel Systems Mech.	42333	M	280	8	5.2	2.6	32.8	.16	.50	.32	7.4	1	309	131	10.6	38	.02	2.3
Airframe Repair Spec.	42735	M	402	6	7.0	2.4	42.3	.47	.68	.18	11.4	1	836	116	11.3	35	.20	3.0
Missile Maintenance Spec.	44330	M	472	8	4.2	2.6	73.4	.23	.27	.44	8.9	0	140	133	11.4	53	.07	3.4
Special Vehicle Mech.	47231	M	362	8	5.4	2.4	30.4	.39	.70	.35	6.3	0	78	MD	11.8	57	.08	2.6
Fire Protection Spec.	57130	M	236	8	2.8	2.7	32.5	.43	.45	.70	4.4	0	203	81	10.5	54	.05	2.1
Aircraft Electrical Systems Spec.	42330	V	552	8	5.0	2.7	35.6	.23	.31	.27	7.3	1	736	124	10.7	75	.14	3.8
Jet Engine Mech.	42632	V	338	8	5.6	2.5	56.1	.27	.34	.27	5.8	1	306	156	10.7	58	.10	2.4
Sheppard Technical Training Center																		
Aircraft Loadmaster	11430	M	212	6	7.1	2.2	30.7	.17	.36	.16	7.0	0	560	115	11.5	29	.07	2.6
Telephone Switching Spec.	36231	M	660	6	4.9	MD[b]	MD	.42	.53	.57	4.5	0	378	103	10.6	147	.10	2.8
Cable Splicing Spec.	36131	M	486	8	5.5	2.7	65.1	.18	.41	.31	8.1	0	136	119	11.7	60	.10	2.0
Tactical Aircraft Maintenance Spec.	43131	M	264	8	5.9	MD	MD	.42	.35	.22	8.1	1	5500	122	9.6	32	.03	2.2
Electrician	54230	M	257	6	3.2	2.8	36.5	.34	.54	.41	8.0	0	231	101	11.0	32	.05	3.2
Carpentry Spec.	55230	M	202	6	4.5	2.4	20.5	.31	.58	.40	6.5	0	206	116	9.8	31	MD	1.4
Financial Services Spec.	67232	M	262	6	6.6	2.5	30.5	.17	.25	.20	10.0	0	286	87	10.9	26	.10	1.4
Medical Services Spec.	90230	M	232	8	23.6	2.9	24.5	.19	.35	.24	4.5	0	1100	91	10.7	49	.06	3.2
Surgical Services Spec.	90232	M	294	8	20.1	2.6	24.0	.22	.39	.29	5.0	0	281	69	11.0	58	.08	3.7
Medical Assistant Spec.	90630	M	220	6	14.9	2.7	16.0	.09	.39	.29	5.9	0	350	77	11.2	39	.04	1.8
Physical Therapy Spec.	91330	M	335	8	8.6	2.6	29.5	.15	.45	.24	11.1	0	52	96	11.4	31	.16	4.3
Dental Assistant Spec.	98130	M	338	6	10.4	2.5	23.0	.19	.41	.17	8.7	0	580	75	10.3	39	.08	3.0
Financial Management Spec.	67231	V	452	6	7.1	2.5	54.1	.15	.28	.26	8.5	0	299	101	11.5	51	.15	2.0
Medical Laboratory Spec.	92430	V	642	8	12.0	2.4	32.2	.54	.38	.24	5.9	0	400	MD	11.0	108	.15	4.6

APPENDIX E: (Continued)

Course Title	Specialty Code	Sample	Course Length (in hours)	Academic Day (in hours)	Student-Faculty Ratio	Instructor Quality	Instructor Experience	Use of Aids	Hands-On Instruction	Feedback	Practice	Reenlistment Bonus	Yearly Flow	Occupational Difficulty	Reading Difficulty	Diversity	Expected Attrition	Abstract Knowledge
Lackland Military Training Center																		
Security Spec.	81130	M	240	8	11.1	2.4	20.1	.35	.54	.22	12.0	1	7767	92	10.6	20	.08	1.6
Law Enforcement Spec.	81132	M	254	8	13.0	2.5	20.6	.11	.22	.49	14.9	0	1982	94	9.7	18	.08	1.4
Lowry Technical Training Center																		
Continuous Photoprocessing	23330	M	328	6	6.0	2.5	24.0	.32	.48	.24	8.0	0	132	70	11.4	40	MD[b]	21
Instrumentation Mech.	31633	M	848	6	4.6	2.5	40.2	.32	.34	.48	4.4	0	188	116	11.6	163	.10	3.
Avionic Sensor Systems Mech.	32232	M	683	6	2.9	2.3	27.1	.38	.58	.53	6.1	1	61	109	11.6	112	.10	3.
Precision Measuring Equipment Spec.	32430	M	1242	6	5.5	2.6	28.3	.18	.33	.20	11.3	0	700	127	12.0	110	.20	4.
Aerospace Ground Equipment Spec.	32630	M	787	6	2.8	2.4	31.1	.35	.28	.45	4.2	0	28	137	12.2	187	.10	3.
Computerized Test Station Spec.	32634	M	712	6	4.6	2.4	12.5	.49	.80	.54	4.3	1	60	MD	11.0	166	.00	3.
Attack Control Systems Spec.	32636	M	255	6	3.0	2.3	21.0	.19	.18	.39	5.5	1	63	123	11.3	36	.10	3.
Munitions Systems Spec.	46130	M	470	6	5.3	2.4	51.5	.39	.38	.35	7.9	0	1500	114	11.2	60	.08	2.
Material Facilities Spec.	64531	M	154	6	12.0	2.5	28.7	.25	.22	.39	4.5	0	911	70	10.3	34	.05	1.
Armament Systems Spec.	47230	V	412	6	6.1	2.8	MD	.40	.51	.25	5.4	0	260	134	11.4	76	.07	3.

APPENDIX E: (Concluded)

Course Title	Specialty Code	Sample	Course Length (in hours)	Academic Day (in hours)	Student-Faculty Ratio	Instructor Quality	Instructor Experience	Use of Aids	Hands-On Instruction	Feedback	Practice	Reenlistment Bonus	Yearly Flow	Occupational Difficulty	Reading Difficulty	Diversity	Expected Attrition	Abstract Knowledge
Keesler Technical Training Center																		
Command and Control Spec.	27430	M	234	8	2.8	2.3	MD[b]	.16	.47	.36	13.0	0	85	95	12.6	18	.02	2.
Wideband Communication Equipment Spec.	30430	M	936	6	5.1	2.4	25.2	.32	.35	.40	7.3	1	420	122	11.9	129	.15	2.
Electronic Computer Spec.	30534	M	1144	6	6.7	2.5	82.3	.17	.16	.28	7.2	1	324	116	11.1	157	.10	2.
Telecommunications Control Spec.	30730	M	700	6	4.5	2.6	38.5	.39	.42	.57	5.3	1	490	118	12.3	132	.15	3.
Airborne Warning Radar Spec.	32832	M	1350	6	3.6	2.3	34.7	.32	.35	.29	9.1	1	120	MD	11.7	148	.10	3.
Electronic Warfare Systems Spec.	32833	M	1425	6	4.8	2.4	48.0	.27	.29	.27	9.0	1	401	119	11.6	158	.15	3.
Computer Spec.	51130	M	185	6	7.5	2.5	22.1	.16	.24	.36	5.6	1	753	72	11.5	33	.05	2.
Administration Spec.	70230	M	208	6	11.8	2.8	29.0	.26	.60	.53	8.3	0	3050	8	11.8	25	.10	1.
Personnel Spec.	73230	M	296	6	8.1	2.5	33.4	.35	.33	.41	10.0	0	1150	80	11.5	29	.06	1.
Personal Affairs Spec.	73231	M	167	8	4.9	2.5	36.1	.31	.33	.44	6.6	0	110	78	11.5	25	.10	1.
Ground Radio Operator	29333	V	292	8	15.7	2.3	40.1	.19	.57	.21	17.7	0	302	90	10.2	17	.03	2.
Aircraft Warning Radar Spec.	30332	V	1198	6	4.6	2.6	66.6	.20	.24	.40	7.7	1	204	136	11.0	156	.14	3.
Navigation Systems Spec.	32831	V	1095	6	MD	2.4	75.1	.32	.30	.36	7.0	1	MD	121	11.3	156	MD[b]	3.
Computer Programming Spec.	51131	V	405	8	5.3	2.4	44.6	.15	.56	.39	6.6	1	290	116	10.7	61	.15	3.

[a]M - Course included in model-development sample; V - Course included in cross-validation sample.

[b]MD - Missing data.

APPENDIX F: STUDENT INPUT VARIABLE MEANS AND STANDARD DEVIATIONS BY COURSE

	Specialty code	Sample	Selector AI		Mechanical		Administrative		General		Electronics		Educational level	
			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Chanute Technical Training Center														
Aircraft Enviromental Sys. Specialist	42331	M	60.1	19.3	59.7	19.3	55.0	19.8	57.5	16.7	58.0	16.6	2.1	.3
Aircraft Fuel System Mechanic	42333	M	61.4	17.5	60.1	17.9	60.0	18.9	59.6	17.0	59.6	17.4	2.1	.3
Airframe Repair Specialist	42735	M	64.5	17.9	63.9	18.4	49.5	21.1	55.7	13.2	59.7	15.1	2.0	.0
Missile Maintenance Specialist	44330	M	62.7	16.0	62.7	16.0	56.1	19.3	56.9	15.0	60.2	17.9	2.0	.2
Special Vehicle Mechanic	47231	M	68.6	16.8	66.7	17.1	55.2	18.3	58.7	17.8	61.2	16.4	2.1	.3
Fire Protection Specialist	57130	M	62.9	15.5	54.7	20.7	56.1	18.9	62.5	15.3	59.2	17.1	2.1	.3
Aircraft Electrical System Specialist	42330	V	74.6	14.1	65.8	20.4	64.3	19.2	68.7	17.3	74.0	14.8	2.1	.4
Jet Engine Mechanic	42632	V	64.5	18.6	64.5	18.7	53.6	19.7	59.2	15.5	60.3	16.9	2.1	.4
Sheppard Technical Training Center														
Aircraft Loadmaster	11430	M	61.7	18.6	59.6	19.0	61.1	19.7	61.5	15.0	61.9	15.4	2.1	.3
Telephone Switching Specialist	36231	M	72.7	15.0	64.7	21.2	63.2	18.8	68.4	16.3	72.5	15.0	2.1	.3
Cable Splicing Specialist	36131	M	58.2	15.4	58.2	15.9	51.3	19.1	57.1	17.3	59.8	16.1	2.1	.4
Tactical Aircraft Maint. Specialist	43131	M	61.2	20.1	61.2	20.1	48.5	19.8	53.4	17.9	57.8	18.2	2.1	.3
Electrician	54230	M	73.9	12.5	63.1	20.3	60.7	20.1	71.9	15.3	73.9	12.5	2.1	.3
Carpentry Specialist	55230	M	62.2	15.7	62.2	15.7	54.1	19.3	58.6	14.9	61.7	16.6	2.0	.2
Financial Services Specialist	67232	M	81.1	11.1	44.5	22.2	81.8	10.1	67.3	17.5	59.6	18.7	2.2	.5
Medical Services Specialist	90230	M	66.9	14.5	49.2	22.3	62.0	18.4	66.7	14.0	61.9	17.9	2.1	.3
Surgical Services Specialist	90232	M	67.6	15.9	51.1	22.4	65.4	19.6	67.6	15.9	63.1	18.0	2.2	.5
Medical Administrative Specialist	90630	M	65.8	14.9	42.2	19.7	66.0	19.0	65.7	14.9	57.9	17.3	2.1	.4
Physical Therapist Specialist	91330	M	75.3	12.0	52.0	23.8	66.0	18.0	75.3	12.0	67.5	14.7	2.2	.5
Dental Assistant Specialist	98130	M	65.7	14.1	45.1	22.4	61.1	19.2	65.5	14.3	59.2	16.5	2.2	.5
Financial Management Specialist	67231	V	82.9	10.1	50.5	26.0	82.9	10.1	74.8	18.4	68.6	19.7	2.4	.4
Medical Laboratory Specialist	92430	V	73.5	14.1	52.2	23.2	69.5	17.8	73.5	14.2	69.4	17.1	2.5	.6
Lackland Technical Training Center														
Security Specialist	81130	M	59.6	14.9	52.2	20.2	57.2	78.7	59.9	14.9	58.0	16.7	2.0	.3
Law Enforcement Specialist	81132	M	64.6	16.0	52.1	21.8	59.6	20.0	64.5	16.0	59.6	18.3	2.1	.4

APPENDIX F: (Continued)

	Specialty code	Sample	Academic motivation		Simple interest		Preference interest		Reading level		Educational preparation		Age	
			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Chanute Technical Training Center														
Aircraft Environmental Sys. Mechanic	42331	M	36.6	14.6	1.3	.48	3.9	1.00	11.1	1.0	1.8	.44	20.2	2.0
Aircraft Fuel Systems Mechanic	42333	M	36.1	13.3	1.5	.50	4.2	.97	11.3	1.1	1.7	.61	19.7	1.9
Airframe Repair Specialist	42735	M	35.7	12.6	1.4	.49	4.3	.95	11.0	1.0	2.2	1.00	20.0	2.0
Missile Maintenanace Specialist	44330	M	34.9	12.9	1.9	.29	5.0	.00	11.0	1.0	1.1	.35	19.7	1.6
Special Vehicle Mechanic	47231	M	36.1	13.5	1.3	.48	4.1	.99	11.1	1.0	1.3	.49	20.1	2.1
Fire Protection Specialist	57130	M	34.8	11.7	1.4	.49	4.5	.86	11.2	1.0	2.0	.61	19.7	1.8
Aircraft Electrical System Specialist	42330	V	44.1	15.1	1.5	.50	4.6	.77	11.6	1.0	.0	.00	20.2	2.0
Jet Engine Mechanic	42632	V	35.3	10.5	1.5	.30	4.7	.68	11.3	1.2	1.4	.49	19.8	2.0
Sheppard Technical Training Center														
Aircraft Loadmaster	11430	M	35.7	10.8	1.3	.49	5.0	.00	11.6	.84	1.7	.42	21.5	3.0
Telephone Switching Specialist	36231	M	41.8	13.4	1.3	.49	4.3	.93	11.5	.92	1.3	.48	19.8	1.7
Cable Splicing Specialist	36131	M	37.4	11.5	1.5	.50	5.0	.00	11.0	.96	1.0	.24	19.8	1.7
Tactical Aircraft Maintenance Specialist	43131	M	36.8	13.3	1.7	.44	4.8	.57	11.1	1.00	1.4	.67	20.3	1.8
Electrician	54230	M	41.5	13.3	1.0	.28	4.3	.96	11.5	1.00	1.1	.39	19.6	1.9
Carpentry Specialist	55230	M	33.4	13.6	1.2	.43	3.9	1.00	11.0	.96	1.3	.47	19.5	1.6
Financial Services Specialist	67232	M	40.0	12.5	1.3	.47	4.2	.97	11.6	.98	1.1	.31	20.1	2.2
Medical Services Specialist	90230	M	37.6	13.1	1.3	.48	4.2	.97	11.4	.94	3.1	1.00	20.0	2.2
Surgical Services Specialist	90232	M	38.0	12.3	1.4	.49	5.0	.00	11.6	1.00	3.4	.99	20.3	2.2
Medical Administrative Specialist	90630	M	37.7	11.9	1.4	.49	4.4	.89	11.4	.87	1.2	.40	20.1	2.4
Physicial Therapist Specialist	91330	M	38.7	11.1	1.0	.50	3.6	.93	11.9	.85	1.9	.64	21.0	2.5
Dental Assistant Specialist	98130	M	38.1	11.3	1.4	.49	4.4	.91	11.5	.94	1.4	.49	20.3	5.6
Financial Management Specialist	67231	V	43.2	13.7	1.6	.48	4.6	.76	11.7	1.00	1.2	.42	20.8	2.1
Medical Laboratory Specialist	92430	V	46.9	11.3	1.5	.50	4.5	.86	11.8	.98	3.7	.86	21.0	2.5
Lackland Military Training Center														
Security Specialist	81130	M	35.4	12.4	1.7	.40	4.8	.58	11.2	.98	1.0	.00	19.3	1.7
Law Enforcement Specialist	81132	M	35.7	11.4	1.3	.49	4.5	.85	11.4	1.00	1.0	.00	19.7	2.1

APPENDIX F: (Continued)

	Specialty code	Sample	Selector AI		Mechanical		Administrative		General		Electronics		Educational level	
			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	S
Lowry Technical Training Center														
Continuous Photoprocessing Specialist	23330	M	66.6	15.1	50.9	21.5	62.5	20.1	66.6	15.1	62.8	17.6	2.3	.6
Instrumentation Mechanic	31633	M	78.7	9.2	71.3	17.1	65.0	22.2	73.3	16.1	78.7	9.2	2.1	.3
Avionic Sensor Systems Specialist	32232	M	79.6	7.8	65.4	22.8	66.0	16.3	72.2	13.4	79.3	7.4	2.1	.4
Precision Measuring Equip. Specialist	32430	M	82.6	10.0	73.3	17.4	72.5	17.4	80.2	15.5	82.6	10.0	2.2	.4
Aerospace Ground Equipment Specialist	32630	M	78.9	8.8	71.2	18.5	65.4	19.9	78.1	11.0	78.9	8.8	2.0	.2
Computerized Test Station Specialist	32634	M	74.0	9.1	65.5	11.9	71.2	17.2	72.0	13.6	74.0	9.1	2.1	.3
Attack Control Systems Specialist	32636	M	76.9	11.2	71.7	16.3	62.0	19.8	71.9	14.3	77.6	10.2	2.2	.5
Munition Systems Specialist	46130	M	62.0	14.0	59.9	15.7	56.0	20.2	59.0	15.0	60.6	15.1	2.1	.3
Material Facilities Specialist	64531	M	61.1	16.4	45.3	21.3	59.9	19.0	60.4	16.3	58.0	17.6	2.1	.4
Armament Systems Specialist	46230	V	59.1	17.9	58.8	18.3	51.9	20.9	57.7	15.2	56.9	14.6	2.0	.3
Keesler Technical Training Center														
Command and Control Specialist	27430	M	63.3	16.9	50.0	23.2	65.0	19.4	62.9	15.6	54.2	22.0	2.4	.6
Wideband Comm. Equipment Specialist	30430	M	77.5	8.4	68.8	18.5	62.8	16.8	72.6	13.2	77.5	8.4	2.2	.4
Electronic Computer Specialist	30534	M	80.5	9.9	69.8	17.9	73.3	16.5	79.2	14.0	80.4	9.4	2.3	.5
Telecommunications Control Specialist	30730	M	76.7	8.9	61.9	18.8	70.0	15.9	71.8	14.4	76.8	8.8	2.2	.5
Airborne Warning Radar Specialist	32832	M	77.5	10.1	71.0	14.8	59.5	15.4	75.5	11.3	77.5	9.6	2.2	.4
Electronic Warfare Systems Specialist	32833	M	81.4	8.9	73.0	16.3	65.8	17.9	76.4	13.4	81.1	9.7	2.2	.4
Computer Specialist	61130	M	83.8	11.2	62.4	21.9	76.3	16.2	83.6	11.6	77.8	15.5	2.2	.5
Administration Specialist	70230	M	68.3	15.8	38.5	19.8	68.3	15.8	57.3	15.0	51.6	17.2	2.1	.4
Personnel Specialist	73230	M	72.3	13.2	39.5	22.0	72.3	13.2	58.2	7.2	52.2	20.0	2.2	.5
Personal Affairs Specialist	73231	M	75.8	15.5	37.2	22.5	75.8	15.5	61.2	19.8	52.4	22.7	2.2	.4
Ground Radio Operator	29333	V	71.5	12.8	42.9	21.4	71.5	12.8	59.8	16.6	56.4	17.9	2.1	.4
Aircraft Warning Radar Specialist	30332	V	81.0	6.9	73.1	15.5	65.0	18.7	76.1	11.9	81.0	6.9	2.2	.5
Navigation Systems Specialist	32831	V	79.6	8.4	72.0	15.9	63.5	18.4	76.7	12.5	79.7	8.1	2.2	.4
Computer Programming Specialist	51131	V	84.0	12.7	70.3	18.1	78.3	12.5	86.6	9.2	84.5	10.1	2.4	.5

APPENDIX F: (Concluded)

	Specialty code	Sample	Academic motivation		Simple interest		Preference interest		Reading level		Educational preparation		Age	
			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Lowry Technical Training Center														
Continuous Photoprocessing Specialist	23330	M	38.9	13.0	1.4	.49	5.0	.00	11.5	1.00	1.4	.59	20.1	2.3
Instrumentation Mechanic	31633	M	45.2	14.5	1.2	.41	5.0	.00	11.7	.91	1.3	.49	20.3	2.3
Avionic Sensor Systems Specialist	32232	M	45.3	14.2	1.3	.47	4.8	.53	11.7	.81	1.9	.83	20.8	1.8
Precision Measuring Equip. Specialist	32430	M	47.3	12.7	1.6	.47	4.7	.60	12.1	.87	1.9	.87	21.1	2.1
Aerospace Ground Equipment Specialist	32630	M	42.5	13.9	1.4	.49	4.4	.92	12.0	.65	1.7	.83	20.1	2.1
Computerized Test Station Specialist	32634	M	45.9	10.8	1.0	.22	3.5	.91	11.7	1.00	1.5	.79	21.2	2.9
Attack Control Systems Specialist	32636	M	43.9	12.4	1.1	.31	3.6	.96	12.0	.90	1.3	.46	21.3	2.7
Munition Systems Specialist	46130	M	38.2	12.0	1.4	.49	4.6	.77	11.1	1.00	.00	.00	19.6	1.9
Material Facilities Specialist	64531	M	37.2	11.2	1.4	.50	4.2	.97	11.0	1.10	1.0	.00	19.7	1.8
Armament Systems Specialist	46230	V	37.1	12.1	1.5	.50	5.0	.00	11.4	1.30	1.3	.49	19.7	1.7
Keesler Technical Training Center														
Command and Control Specialist	27430	M	34.0	10.9	1.4	.51	5.0	.00	11.8	1.00	.0	.00	22.2	3.3
Wideband Comm. Equipment Specialist	30430	M	41.7	13.0	1.6	.48	4.5	.83	11.7	.78	1.2	.44	20.5	2.0
Electronic Computer Specialist	30534	M	45.0	14.7	1.4	.50	4.6	.80	12.0	.74	1.3	.49	21.2	2.6
Telecommunications Control Specialist	30730	M	45.0	13.7	1.3	.48	5.0	.00	11.6	.93	1.2	.45	20.4	2.0
Airborne Warning Radar Specialist	32832	M	40.9	13.3	1.4	.50	4.3	.97	11.8	.84	1.2	.45	21.2	2.4
Electronic Warfare Systems Specialist	32833	M	48.1	15.0	1.2	.41	3.8	.99	12.0	.79	1.3	.46	20.8	1.6
Computer Specialist	61130	M	44.4	14.7	1.4	.49	4.6	.74	12.2	.70	1.0	.10	20.7	2.5
Administration Specialist	70230	M	37.3	13.0	1.4	.49	4.1	.97	11.0	1.00	1.5	.70	20.0	2.3
Personnel Specialist	73230	M	37.2	12.3	1.3	.47	4.3	.93	11.1	1.00	1.3	.48	20.4	2.4
Personal Affairs Specialist	73231	M	37.0	13.4	1.5	.50	4.5	.87	11.4	1.10	1.4	.50	20.7	2.8
Ground Radio Operator	29333	M	39.0	15.5	1.4	.49	4.2	.96	11.0	1.10	1.3	.48	20.0	2.3
Aircraft Warning Radar Specialist	30332	V	45.2	13.7	1.4	.49	4.2	.96	11.9	.78	1.4	.49	20.8	2.1
Navigation Systems Specialist	32831	V	44.5	11.0	1.5	.49	4.5	.85	11.9	.95	1.2	.44	21.3	2.3
Computer Programming Specialist	51131	V	45.7	13.5	1.2	.49	4.8	.60	12.6	.24	2.8	.40	22.4	3.0

Note. The selector AI and the ASVAB composite scores (Mechanical, Administrative, General, and Electronics) were obtained from different sources. This accounts for minor differences in the selectic AI and composite scores.

APPENDIX G: TRAINING OUTCOME VARIABLE MEANS AND STANDARD DEVIATIONS BY COURSE

			Quality of performance		SIA time		Academic counseling		Nonacad. counseling		Retraining time		Academic attrition		Nonacad. attrition	
Chanute Technical Training Center	AFSC		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	S
Aircraft Enviromental Systems Mechanic	42331	M[a]	86.6	5.5	61.9	30.1	6.80	8.0	.40	.88	29.2	62.5	.03	.17	.00	.00
Aircraft Fuel Systems Mechanic	42333	M	87.5	6.4	1.5	2.6	.62	1.3	.20	.62	11.6	26.5	.00	.00	.00	.00
Airframe Repair Specialist	42735	M	84.9	8.1	21.3	13.4	.46	1.2	.09	.29	9.1	25.0	.01	.11	.00	.00
Missile Maintenance Specialist	44330	M	89.1	4.8	5.8	5.2	2.10	2.3	.09	.34	.0	.0	.0(	.00	.00	.00
Special Vehicle Mechanic	47231	M	88.0	6.0	52.8	25.7	.83	3.1	.00	.00	6.5	37.0	.03	.17	.00	.00
Fire Protection Specialist	57130	M	89.8	5.7	2.5	3.5	.68	1.6	.10	1.00	18.9	44.1	.04	.19	.00	.00
Aircraft Electrical Sys. Specialist	42330	V	90.0	6.3	3.8	5.5	2.30	3.1	.10	.58	8.8	38.0	.02	.14	.00	.00
Jet Engine Mechanic	42632	V	85.0	8.9	4.6	6.5	.70	2.7	.16	1.70	16.5	60.2	.03	.17	.00	.00
Sheppard Technical Training Center																
Aircraft Loadmaster	11430	M	87.5	6.1	4.2	4.9	.57	1.10	.02	.16	14.1	37.5	.03	.16	.00	.00
Telephone Switching Specialist	36231	M	83.5	5.1	8.2	8.1	1.90	4.20	.09	.35	45.5	151.0	.07	.26	.00	.00
Cable Splicing Specialist	36131	M	81.9	13.0	6.4	6.1	.77	.80	.05	.22	16.2	65.6	.03	.16	.00	.00
Tactical Aircraft Maint. Specialist	43131	M	82.7	7.0	.0	.0	.00	.00	.00	.00	.0	.0	.00	.00	.00	.00
Electrician	54230	M	87.9	6.7	1.5	2.8	.11	.47	.02	.12	2.9	13.6	.00	.00	.00	.00
Carpentry Specialist	55230	M	84.4	4.9	1.2	4.5	.09	.30	.00	.00	3.3	11.6	.00	.00	.00	.00
Financial Service Specialist	67232	M	84.8	6.2	3.9	5.1	.20	.65	.00	.00	2.4	13.3	.00	.00	.00	.00
Medical Services Specialist	90230	M	82.2	5.7	16.7	26.2	1.60	3.00	.15	.53	4.2	24.8	.00	.00	.01	.06
Surgical Services Specialist	90320	M	85.3	6.6	8.1	16.5	1.40	2.20	.32	.83	1.0	7.0	.00	.00	.00	.00
Medical Administrative Specialist	90630	M	83.2	5.5	7.5	19.9	1.60	5.90	.38	1.80	7.1	37.1	.03	.16	.01	.08
Physical Therapy Specialist	91330	M	77.8	17.1	2.2	3.5	1.60	2.30	.12	.42	3.9	26.9	.08	.28	.05	.22
Dental Assistant Specialist	98130	M	87.9	5.1	6.4	12.6	2.40	2.50	.04	.20	13.7	62.8	.02	.18	.01	.11
Financial Management Assistant	67231	V	86.4	6.7	10.3	9.1	1.30	4.20	.05	.29	25.0	70.5	.06	.23	.00	.00
Medical Laboratory Specialist	92430	V	84.9	5.1	24.4	24.6	2.50	3.50	.11	.39	53.7	131.5	.11	.32	.00	.00
Lackland Military Training Center																
Security Specialist	81130	M	79.4	6.7	.54	1.5	1.5	3.3	.51	3.2	8.20	40.8	.03	.16	.01	.08
Law Enforcement Specialist	81132	M	80.1	6.1	1.20	3.4	1.3	3.2	.50	2.9	.61	5.5	.02	.12	.02	.15

APPENDIX G: (Concluded)

			Quality of performance		SIA time		Academic counseling		Nonacad. counseling		Retraining time		Academic attrition		Nonacad. attrition	
Lowry Technical Training Center	AFSC		$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	S
Continuous Photoprocessing Specialist	23330	M[a]	82.2	8.5	2.4	7.4	1.30	3.90	.02	.14	15.40	63.50	.06	.23	.00	.0
Instrumentation Mechanic	31633	M	89.9	4.8	22.6	25.1	1.80	4.40	.00	.00	19.60	79.40	.12	.33	.00	.0
Avionic Sensor Systems Specialist	32232	M	84.9	7.8	3.4	5.3	.78	1.20	.03	.17	6.80	21.40	.00	.00	.00	.0
Precision Measuring Equip. Specialist	32430	M	84.2	5.0	18.0	16.5	.99	1.20	.01	.08	.11	1.20	.01	.12	.00	.0
Aerospace Ground Equipment Specialist	32630	M	90.3	4.5	4.2	5.9	.62	1.60	.00	.00	22.60	116.10	.05	.21	.00	.0
Computerized Test Station Specialist	32634	M	92.6	3.9	8.6	15.1	.40	.70	.15	.36	.00	.00	.00	.00	.00	.0
Attack Control Systems Specialist	32636	M	84.5	5.1	9.6	12.8	1.30	2.40	.12	.79	20.61	61.58	.06	.24	.00	.0
Munition Systems Specialist	46130	M	84.5	8.7	2.6	4.0	1.20	4.50	.05	.47	11.30	59.00	.04	.20	.00	.0
Material Facilities Specialist	64531	M	86.4	6.2	1.0	1.6	.16	.50	.01	.07	2.00	11.00	.00	.00	.00	.0
Armament Systems Specialist	46230	V	85.9	7.5	1.5	2.6	.89	2.70	.07	.40	14.90	78.90	.05	.20	.00	.0
Keesler Technical Training Center																
Command and Control Specialist	27430	M	89.7	5.7	2.30	8.4	.19	.67	.00	.00	.00	.00	.00	.00	.00	.0
Wideband Comm. Equip. Specialist	30430	M	89.4	4.5	6.30	6.6	3.00	3.60	.09	.33	27.30	60.60	.03	.16	.00	.0
Electronic Computer Specialist	30534	M	91.2	4.5	3.60	7.0	2.80	3.50	.03	.17	15.80	37.50	.01	.10	.00	.0
Telecommunications Control Specialist	30730	M	90.3	4.6	2.60	6.0	1.80	2.60	.07	.38	9.00	23.30	.02	.15	.00	.0
Airborne Warning Radar Specialist	32832	M	89.4	4.1	5.50	10.1	3.20	7.50	.00	.00	15.70	53.80	.10	.30	.00	.0
Electronic Warfare Radar Specialist	32833	M	91.2	4.2	6.20	16.5	3.10	4.00	.16	.47	18.20	70.90	.02	.13	.00	.0
Computer Specialist	61130	M	86.9	7.8	.29	1.0	.35	1.40	.01	.07	2.00	10.40	.01	.07	.00	.0
Administration Specialist	70230	M	89.5	6.0	1.30	3.4	1.00	4.60	.04	.28	7.50	30.30	.02	.15	.00	.0
Personnel Specialist	73230	M	87.2	6.4	1.60	6.0	1.10	1.60	.05	.28	5.60	20.00	.02	.12	.00	.0
Personal Affairs Specialist	73231	M	87.7	5.6	.38	1.8	.16	.44	.00	.00	1.70	14.50	.00	.00	.00	.0
Ground Radio Operator	29333	V	86.6	5.6	12.50	14.4	2.80	4.40	.03	.20	28.00	66.20	.06	.24	.00	.0
Aircraft Warning Radar Specialist	30332	V	89.5	4.4	10.90	9.2	2.10	3.20	.06	.23	13.90	41.00	.04	.18	.00	.0
Navigation Systems Specialist	32831	V	90.5	4.4	3.30	8.8	1.40	1.80	.05	.22	14.00	31.70	.01	.11	.00	.0
Computer Programming Specialist	51131	V	87.9	6.9	5.80	19.8	.60	1.30	.02	.14	9.20	22.30	.00	.09	.00	.0

[a]M - Course included in model-development sample; V - Course included in cross-validation sample.

APPENDIX H: INTERCORRELATIONS OF STUDENT INPUT, COURSE CONTENT, AND TRAINING OUTCOME VARIABLES IN THE TOTAL SAMPLE

	Variables[a]	SI-1	SI-2	SI-3	SI-4	SI-5	SI-6	SI-7	SI-8	SI-9	SI-10	SI-11	SI-12	CC-1	CC-2	CC-3	CC-4	CC-5	CC-6
SI-1	Aptitude Selector	1.00	.48	.48	.73	.64	.51	.35	-.17	-.12	.18	.09	.18	.27	-.23	-.13	.01	.14	-.12
SI-2	Mechanical		1.00	.06	.47	.66	.42	.26	-.04	.00	.08	.02	.10	.30	-.07	-.25	-.14	.18	.04
SI-3	Administration			1.00	.45	.29	.35	.27	-.05	-.05	.17	.08	.11	.06	-.14	.00	.05	.02	-.13
SI-4	General				1.00	.76	.66	.36	-.09	-.04	.20	.15	.20	.25	-.13	-.07	-.02	.06	-.13
SI-5	Electronics					1.00	.52	.41	-.07	-.01	.19	.10	.18	.36	-.15	-.18	-.08	.15	-.04
SI-6	Reading Level						1.00	.26	-.05	.00	.18	.12	.19	.19	-.09	-.06	-.02	.05	-.09
SI-7	Academic Motivation							1.00	-.06	-.04	.31	.25	.26	.21	-.12	-.08	-.02	.04	-.01
SI-8	Simple Interest								1.00	.70	-.04	-.04	-.09	-.01	.14	.04	-.08	-.02	.07
SI-9	Preference Interest									1.00	-.05	.00	-.03	.00	.11	-.01	-.08	.01	.04
SI-10	Educational Level										1.00	.13	.44	.08	-.05	-.02	-.02	.05	-.02
SI-11	Educational Preparation											1.00	.10	.00	.27	.37	.19	-.10	.16
SI-12	Age												1.00	.15	-.11	-.07	-.01	.09	-.05
CC-1	Course Length													1.00	-.36	-.40	-.17	.51	.09
CC-2	Day Length														1.00	.40	-.19	-.14	.04
CC-3	Student-Faculty Ratio															1.00	.37	-.41	-.28
CC-4	Instructor Quality																1.00	-.03	-.31
CC-5	Instructor Experience																	1.00	.03
CC-6	Aids in Use																		1.00
CC-7	Hands-On Practice																		
CC-8	Amount of Feedback																		
CC-9	Practice																		
CC-10	Reenlistment Bonus																		
CC-11	Student Flow																		
CC-12	Ocupational Difficulty																		
CC-13	Reading Difficulty																		
CC-14	Diversity																		
CC-15	Abstract Knowledge																		
CC-16	Expected Attrition																		
TO-1	Quality of Performance																		
TO-2	SIA Time																		
TO-3	Academic Counseling																		
TO-4	Nonacadmeic Counseling																		
TO-5	Retraining Time																		
TO-6	Academic Attrition																		
TO-7	Nonacademic Attrition																		

Variables[a]	CC-7	CC-8	CC-9	CC-10	CC-11	CC-12	CC-13	CC-14	CC-15	CC-16	TO-1	TO-2	TO-3	TO-4	TO-5	TO-6	TO-7
SI-1 Aptitude Selector	-.24	.04	-.10	.00	-.24	.04	.25	.28	.21	.23	.37	-.03	-.15	-.06	-.09	-.08	-.03
SI-2 Mechanical	-.11	-.05	-.08	.23	-.10	.34	.06	.31	.28	.18	.26	.00	-.11	-.02	-.07	-.08	-.01
SI-3 Administration	-.12	.02	-.03	-.09	-.13	-.13	.17	.07	.03	.09	.25	-.05	-.13	-.06	-.07	-.06	-.03
SI-4 General	-.23	-.01	-.11	.07	-.17	.04	.13	.28	.26	.17	.34	-.04	-.14	-.04	-.04	-.08	-.02
SI-5 Electronics	-.21	-.02	-.13	.17	-.17	.21	.15	.38	.34	.24	.34	-.01	-.11	-.05	-.07	-.08	-.04
SI-6 Readinig Level	-.18	-.04	-.08	.05	-.13	.06	.10	.20	.20	.15	.33	-.05	-.16	-.02	-.10	-.09	-.01
SI-7 Academic Motivation	-.12	-.01	-.08	.04	-.12	.06	.13	.22	.19	.17	.21	-.01	-.07	-.04	-.03	-.04	-.04
SI-8 Simple Interest	.05	-.15	.12	.15	.25	.02	-.03	-.06	-.08	.00	-.09	-.04	.01	.02	.00	.01	.00
SI-9 Preference Interest	-.01	-.12	.07	.11	.14	.06	-.01	-.02	.00	-.03	-.05	-.06	-.01	.01	-.01	.01	.00
SI-10 Educational Level	-.09	-.02	-.04	-.02	-.10	-.01	.07	.09	.08	.10	.15	.00	-.03	-.03	.00	-.03	-.02
SI-11 Educational Preparation	.04	.06	-.28	-.16	-.18	-.11	-.04	.09	.43	.12	.01	.17	-.02	.00	.02	.01	-.01
SI-12 Age	-.10	.00	-.08	.00	-.16	.03	.13	.15	.15	.14	.16	.02	-.01	-.02	.02	.02	-.01
CC-1 Course Length	-.30	-.10	-.08	.24	-.29	.50	.37	.89	.60	.66	.20	.15	.11	-.03	.07	.01	-.02
CC-2 Day Length	.07	-.08	.24	.15	.38	-.03	-.54	-.36	-.14	-.27	-.26	-.01	-.01	.06	-.01	.01	.04
CC-3 Student-Faculty Ratio	.07	.04	.11	-.23	.25	-.55	-.30	-.36	-.17	-.28	-.20	.01	.01	.04	-.03	.00	.02
CC-4 Instructor Quality	.04	.54	-.37	-.50	-.21	-.31	.19	-.09	.03	-.10	.08	-.01	-.05	-.02	-.06	-.01	.00
CC-5 Instructor Experience	-.30	.00	-.18	.06	-.40	.59	.25	.52	.30	.24	.24	.05	.03	-.05	.05	.00	-.02
CC-6 Aids in Use	.45	-.04	-.11	.31	.28	.16	.17	.16	.13	.06	.00	.15	.05	.00	.01	.05	-.04
CC-7 Hands-On Practice	1.00	-.07	.18	.05	.45	-.18	.03	-.33	-.14	.02	-.09	.09	.01	.02	.01	.01	-.01
CC-8 Amount of Feedback		1.00	-.45	-.34	-.31	-.19	.10	.06	-.11	-.26	.17	-.03	-.04	-.02	-.02	-.01	.00
CC-9 Practice			1.00	.14	.49	-.07	-.31	-.40	-.35	.07	-.24	-.12	.04	.06	-.03	.00	.05
CC-10 Reenlistment Bonus				1.00	.45	.42	-.07	.21	.08	.15	-.06	.00	.08	.05	.03	-.01	.00
CC-11 Student Flow					1.00	-.20	-.23	-.42	-.46	-.23	-.30	-.20	.00	.08	-.04	-.01	.02
CC-12 Ocupational Difficulty						1.00	.03	.53	.46	.45	.07	.09	.04	.00	.06	.01	.00
CC-13 Reading Difficulty							1.00	.41	.28	.43	.26	.03	-.01	-.06	.01	.01	-.04
CC-14 Diversity								1.00	.67	.56	.25	.17	.10	-.04	.09	.03	-.03
CC-15 Abstract Knowledge									1.00	.56	.13	.32	.09	-.04	.08	.05	-.64
CC-16 Expected Attrition										1.00	.09	.20	.07	-.02	.07	.04	-.01
TO-1 Quality of Performance											1.00	-.08	-.30	-.09	-.20	-.22	-.07
TO-2 SIA Time												1.00	.28	.01	.18	.12	-.01
TO-3 Academic Counseling													1.00	.21	.52	.52	.05
TO-4 Nonacadmeic Counseling														1.00	.18	.16	.43
TO-5 Retraining Time															1.00	.68	.11
TO-6 Academic Attrition																1.00	.00
TO-7 Nonacademic Attrition																	1.00

[a]Student input variable are denoted by the abbreviation SI. Course Content variables are denoted by the abbreviation CC. Training outcome variables are denoted by the abbreviation TO.

Note. Correlations are based on 5,981 students and 48 courses.

APPENDIX I: INTERCORRELATIONS OF STUDENT INPUT, COURSE CONTENT, AND TRAINING OUTCOME VARIABLES IN THE CROSS-VALIDATION SAMPLE

Variables[a]		SI-1	SI-2	SI-3	SI-4	SI-5	SI-6	SI-7	SI-8	SI-9	SI-10	SI-11	SI-12	CC-1	CC-2	CC-3	CC-4	CC-5	CC-6
SI-1	Aptitude Selector	1.00	.50	.46	.61	.63	.39	.28	.00	.01	.16	.07	.17	.25	-.17	.00	-.15	.07	-.12
SI-2	Mechanical		1.00	.13	.42	.65	.39	.25	.04	.13	.02	-.03	.08	.24	-.12	-.36	.18	.29	-.06
SI-3	Administration			1.00	.53	.34	.35	.27	.10	.00	.23	.14	.17	.01	-.06	.18	-.23	-.15	-.08
SI-4	General				1.00	.78	.65	.39	.08	.03	.25	.21	.26	.29	-.15	-.06	-.09	.03	.03
SI-5	Electronics					1.00	.52	.43	.06	.06	.22	.14	.21	.38	-.17	-.18	.00	.15	.00
SI-6	Readinig Level						1.00	.28	.10	.09	.20	.17	.16	.19	-.11	-.09	.02	.04	.06
SI-7	Academic Motivation							1.00	.03	.03	.35	.33	.37	.18	-.02	.04	-.08	-.06	.11
SI-8	Simple Interest								1.00	.63	.05	-.02	-.05	.00	-.06	-.02	.04	.02	.05
SI-9	Preference Interest									1.00	.02	.01	.00	-.09	.00	-.14	.13	.02	.00
SI-10	Educational Level										1.00	.27	.49	.05	.01	.08	-.12	-.10	.[illegible]3
SI-11	Educational Preparation											1.00	.22	.05	.41	.28	-.24	-.63	.71
SI-12	Age												1.00	.14	-.05	.00	-.09	.01	.04
CC-1	Course Length													1.00	-.55	-.24	.08	.48	.16
CC-2	Day Length														1.00	.41	-.43	-.71	.32
CC-3	Student-Faculty Ratio															1.00	-.73	-.69	.34
CC-4	Instructor Quality																1.00	.27	-.16
CC-5	Instructor Experience																	1.00	-.44
CC-6	Aids in Use																		1.00
CC-7	Hands-On Practice																		
CC-8	Amount of Feedback																		
CC-9	Practice																		
CC-10	Reenlistment Bonus																		
CC-11	Student Flow																		
CC-12	Occupational Difficulty																		
CC-13	Reading Difficulty																		
CC-14	Diversity																		
CC-15	Abstract Knowledge																		
CC-16	Expected Attrition																		
TO-1	Quality of Performance																		
TO-2	SIA Time																		
TO-3	Academic Counseling																		
TO-4	Nonacadmeic Counseling																		
TO-5	Retraining Time																		
TO-6	Academic Attrition																		
TO-7	Nonacademic Attrition																		

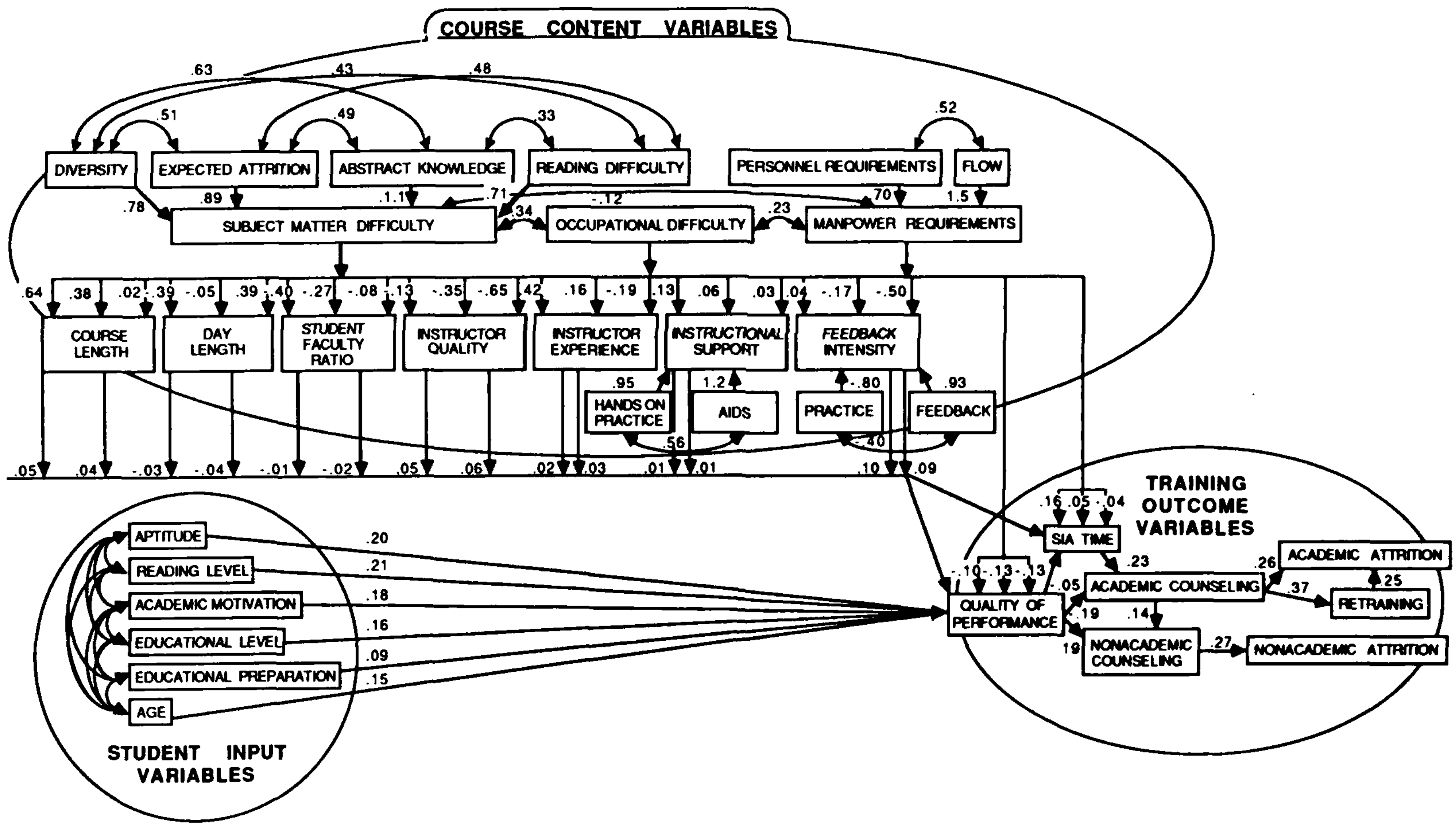
APPENDIX I: (Concluded)

Variables[a]		CC-7	CC-8	CC-9	CC-10	CC-11	CC-12	CC-13	CC-14	CC-15	CC-16	TO-1	TO-2	TO-3	TO-4	TO-5	TO-6	TO-7
SI-1	Aptitude Selector	-.15	.24	.06	.02	-.03	-.27	.13	.23	.04	.38	.33	-.08	-.14	.00	-.15	-.15	.00
SI-2	Mechanical	-.22	.37	-.26	.41	.00	.31	.10	.27	.09	-.15	.32	-.25	-.24	.00	-.20	-.19	.02
SI-3	Administrative	.02	-.01	.19	-.23	-.03	-.43	.06	.01	-.03	.44	.24	-.01	-.10	-.06	-.07	-.08	-.07
SI-4	General	-.16	.30	-.11	.12	.00	-.14	.21	.34	.22	.42	.39	-.08	-.20	-.02	-.18	-.16	-.02
SI-5	Electronics	-.23	.41	-.17	.28	.04	-.01	.18	.41	.24	.30	.40	-.15	-.21	-.03	-.19	-.18	-.03
SI-6	Readinig Level	-.14	.18	-.14	.10	.00	.00	.17	.24	.16	.21	.37	-.12	-.25	-.01	-.23	-.21	.00
SI-7	Academic Motivation	-.10	.10	-.04	.06	.08	-.09	.08	.20	.18	.27	.21	-.01	-.07	.00	-.01	-.02	-.01
SI-8	Simple Interest	-.10	-.05	-.06	-.03	.03	.01	.12	.04	-.01	.00	.05	-.06	-.05	.03	-.02	.00	-.03
SI-9	Preference Interest	-.02	-.01	-.14	.03	.01	.13	.08	-.03	-.03	-.10	.09	-.09	-.12	.01	-.07	-.04	.01
SI-10	Educational Level	-.03	.00	-.04	-.03	-.01	-.10	.09	.10	.10	.22	.11	.02	-.02	-.02	.00	-.01	-.01
SI-11	Educational Preparation	.10	-.15	-.30	.20	.71	.01	.04	.18	.66	.47	-.03	.31	.04	.02	.09	.08	.01
SI-12	Age	-.03	.16	-.06	.07	-.01	-.09	.10	.16	.14	.26	.15	-.02	.02	.06	.03	.00	.07
CC-1	Course Length	-.57	.72	-.25	.42	-.09	.08	.41	.94	.54	.44	.19	.05	.05	-.01	.00	-.01	-.02
CC-2	Day Length	.41	-.46	.13	.22	.54	.14	-.76	.66	.00	-.36	-.14	.15	.05	.02	.06	.04	.02
CC-3	Student-Faculty Ratio	.57	-.66	.68	-.64	.09	-.72	-.44	-.36	.09	.48	-.07	.31	.18	-.01	.12	.10	-.02
CC-4	Instructor Quality	-.27	.18	-.50	.06	.08	.09	.45	.19	.11	-.19	.03	-.23	-.09	.01	-.08	-.04	.00
CC-5	Instructor Experience	-.53	.67	-.19	.44	-.64	.06	.37	.44	-.29	-.49	.14	-.31	-.13	.00	-.12	-.18	.01
CC-6	Aids in Use	-.03	-.28	-.43	.46	.35	.57	.16	.34	.74	.19	-.11	.31	.07	.02	.14	.11	.00
CC-7	Hands-On Practice	1.00	-.42	.52	-.48	-.01	-.41	-.52	-.72	-.01	.10	-.07	.02	.04	-.02	.02	.01	-.01
CC-8	Amount of Feedback		1.00	-.34	.66	-.28	.27	.26	.66	.22	.08	.20	-.16	-.07	-.01	-.09	-.09	.00
CC-9	Practice			1.00	-.58	-.12	-.78	-.58	-.52	-.43	.49	.03	.04	.13	-.03	.00	.00	-.01
CC-10	Reenlistment Bonus				1.00	.27	.70	-.10	.52	.37	-.53	.08	-.15	-.08	.03	-.08	-.08	.02
CC-11	Student Flow					1.00	.03	-.23	-.06	.39	.10	.03	.06	.08	.01	.02	.02	.00
CC-12	Ocupational Difficulty						1.00	.07	.25	.15	-.92	-.07	-.22	-.15	.05	-.06	-.04	.04
CC-13	Reading Difficulty							1.00	.77	.25	.62	.04	-.02	-.07	.00	.00	.00	-.01
CC-14	Diversity								1.00	.68	.61	.15	.07	.01	.00	.01	.00	-.02
CC-15	Abstract Knowledge									1.00	.55	.05	.21	.08	.00	.07	.05	-.03
CC-16	Expected Attrition										1.00	.09	.29	.16	-.03	.08	.07	-.06
TO-1	Quality of Performance											1.00	-.38	-.54	-.09	-.46	-.40	-.07
TO-2	SIA Time												1.00	.51	.07	.37	.33	.01
TO-3	Academic Counseling													1.00	.16	.69	.69	.12
TO-4	Nonacademic Counseling														1.00	.07	.02	.93
TO-5	Retraining Time															1.00	.78	.02
TO-6	Academic Attrition																1.00	.00
TO-7	Nonacademic Attrition																	1.00

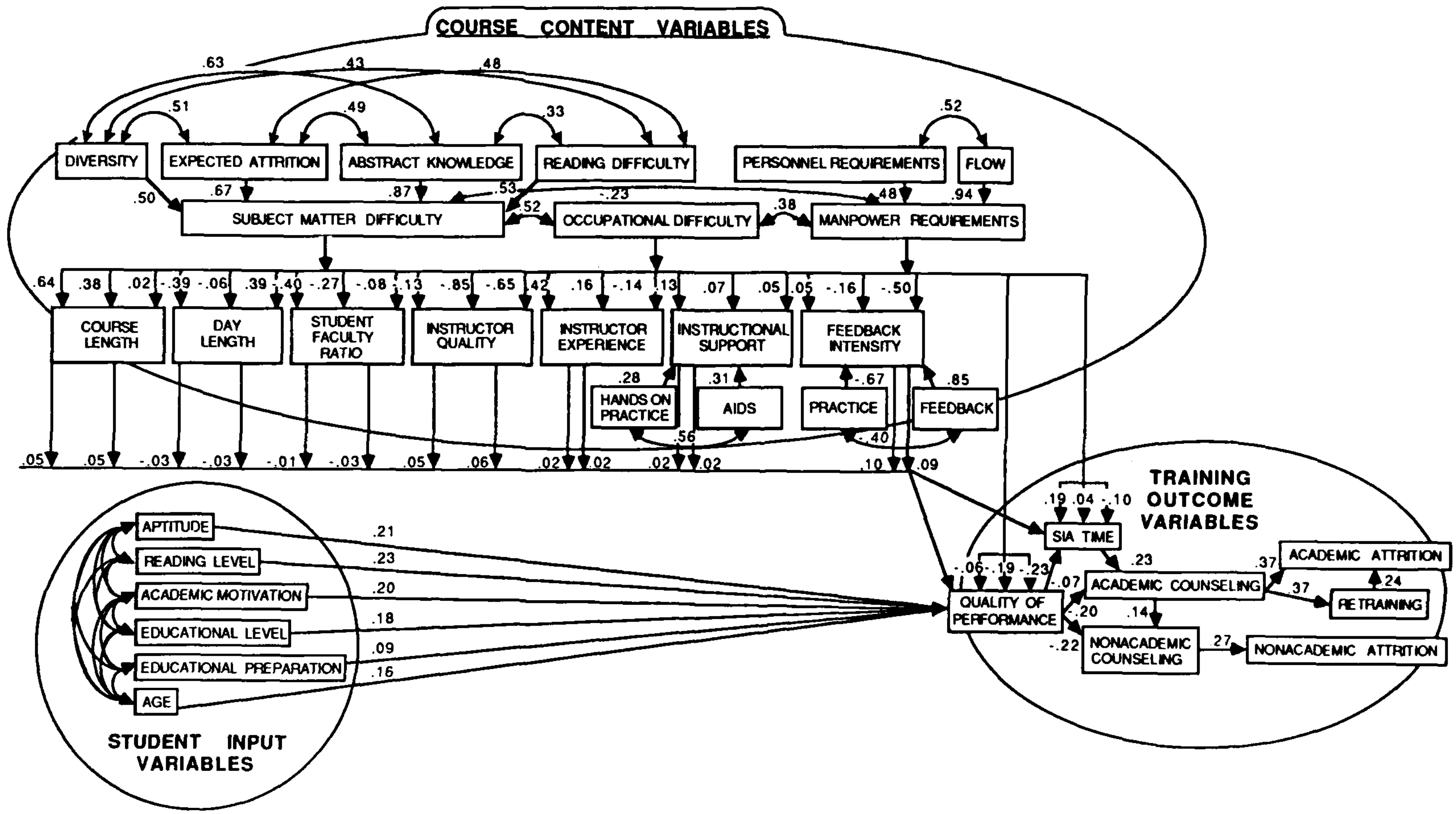
[a]Student input are denoted by the abbreviation SI. Course Content variables are denoted by the abbreviation CC. Training outcome variables are denoted by the abbreviation TO.

Note. Correlations are based on 890 students and 9 courses.

APPENDIX J: REFINED MODEL WITH REGRESSION COEFFICIENTS



APPENDIX K: REFINED MODEL WITH TOTAL EFFECTS



APPENDIX L: CORRELATED ERROR TERMS AMONG COURSE VARIABLES

Course content variables[a]	Course length	Day length	Student-faculty ratio	Instructor quality	Instructor experience	Instructional support	Feedback intensity
Day Length	.02	.63					
Student-Faculty Ratio	.02	.23	.62				
Instructor Quality	.12	.00	.12	.52			
Instructor Experience	.02	.13	-.24	.01	.65		
Instructional Support	.14	.01	.16	.00	.16	.63	
Feedback Intensity	.54	.38	.04	.00	.05	.03	.64

[a]All observed scores are assumed to be a function of true plus error variance. Correlations represent projected relationships among errors of observations on the variables.

APPENDIX M: CORRELATED ERROR TERMS OF COURSE CONTENT AND TRAINING OUTCOME VARIABLES

	Outcome Variables						
Course content variables[a]	Assessed quality	SIA time	Academic counseling	Nonacademic counseling	Retraining time	Academic attrition	Nonacademic attrition
Course Length	-.08	-.08	.14	.03	.10	-.02	.00
Day Length	-.12	.01	-.03	.11	-.13	.01	.14
Student-Faculty Ratio	-.05	-.02	-.02	-.03	-.12	.01	.60
Instructor Quality	.02	.00	.01	.01	.01	.00	.00
Instructional Support	-.03	.05	.05	-.01	.01	.00	-.08
Feedback Intensity	-.07	.02	.00	-.03	.29	-.04	.00

[a]All observed scores are assumed to be a function of true plus error variance. Correlations represent projected relationships among errors of observations on the variables.

APPENDIX N: CORRELATED ERROR TERMS AMONG TRAINING OUTCOME VARIABLES

Training outcome variables[a]	Assessed quality performance	SIA time	Academic counseling	Nonacademic counseling	Retraining time	Academic attrition	Nonacademic attrition
Assessed Quality of Performance	.46						
SIA Time	-.16	.87					
Academic Counseling	-.37	.32	.63				
Nonacademic Counseling	-.10	.00	.23	.75			
Retraining Time	-.09	.12	.55	.17	.47		
Academic Attrition	-.14	.04	.34	-.09	.34	.30	
Nonacademic Attrition	-.12	.01	.11	.59	.04	-.03	.64

[a]All observed scores are assumed to be a function of true plus error variance. Correlations represent projected relationships among errors of observations on the variables.

END

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